ASTRONOMY

JUN 29 1949

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Vol. VIII, No. 9
JULY, 1949
Whole Number 93
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Stellar Associations

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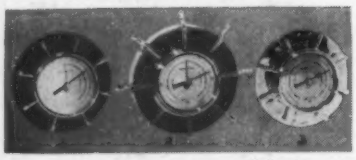

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In Focus

OF THE MANY drawings of the Hale telescope by the late Russell W. Porter, our back cover this month is perhaps one of the most interesting in detail and subject. Much is published today about "mechanical brains," machines to do man's complicated problems, and it is surprising that more has not been written about the driving mechanism of the 200-inch telescope. A computer that automatically corrects for refraction and for deformation in an instrument whose moving parts weigh 500 tons, corrects for errors in the gears and elsewhere, and that will keep the telescope pointed to within one second of arc of a point on the celestial sphere is truly a mechanical brain.

Bruce Rule has described the engineering aspects of the 200-inch instrument, and it is from his talk at last summer's meetings that most of the following detailed information has been taken. The precise drive for the telescope involves the co-ordination of driving elements principally contained in two boxes, one for the declination drive inside the west yoke tube, the other for right ascension and computers in the cabinet below the south pedestal pictured on the back cover. In each of these boxes is included the gearing for several driving speeds over a range of one to 1,800 for manual speeds and one to 36,000 for automatic controls. Included also are the necessary Selsyn indicators, correcting rate drives, integrators, clutches, and electrical limits. The south box contains, in addition, the tracking drive, sidereal time, rate computers, phantom telescope, and an automatic printing recorder of position and guide operations. This latter recorder will accumulate refraction and periodic error data over an extended operating period, which data will be used to determine the final shape of three-dimensional correction computer cams.

At the top of the picture is the hollow tube through which light from the telescope, when used in the f/30 coude combination, will pass to the temperature-controlled spectrograph room behind the south pier.

Surrounding this tube are the two 14-foot, 720-tooth worm gears. They are bolted together and supported on bearings at the pier, and they drive the telescope in right ascension through a diaphragm and torque tube. Since the desired accuracy of drive is one second of arc in one hour at one revolution per day, and since the short-period errors are limited to 1/10 second of arc per five seconds of time, extreme precision in cutting the gears was required. One second of arc is equivalent to only 0.000445 inch on the pitch circle of the gear.

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BACK COVER: The right-ascension drive and computer of the 200-inch telescope, Palomar Observatory, California, drawn by Russell W. Porter. Courtesy California Institute of Technology. (See In Focus.)

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Fig. 1. The field of the Double Cluster in Perseus. Yerkes Observatory photograph by E. E. Barnard.

STELLAR ASSOCIATIONS

By Otto Struve, *Yerkes and McDonald Observatories*

ONE of the most remarkable properties of the stars is their tendency to form closely connected groups or clusters. The Pleiades, Praesepe, and the cluster in Coma Berenices are visible to the naked eye and have been known in ancient times. The Double Cluster in Perseus was recorded by Hipparchus, but was not resolved by him into separate stars. Similarly, Praesepe was known only as a diffuse luminous spot in the night sky, and it remained for Galileo in 1610 to announce that with his telescope he could see "the nebula called Praesepe, not as one star only, but as a mass of more than 40 small stars."

In the past three centuries several hundred star clusters have been discovered. These fall into two large groups. The globular clusters, which are distinct groups associated with our galactic system, present a more-or-less spherical arrangement concentric with the flattened stellar system of the Milky Way, but they are not sharing its rotation and other dynamical properties. The other group consists of approximately 200 galactic clusters, ranging from inconspicuous groupings of a few stars, barely distinguishable on the background of the Milky Way, to closely knit clusters consisting of several hundred stars of different luminosities, temperatures, and masses. The galactic clusters are strongly concentrated toward the central plane of the Milky Way; Harlow Shapley has listed only 15 that have galactic latitudes in excess of 15°. Among them are all the brighter clusters, as well as those which occupy an appreciable area in the sky.

A few galactic clusters are sufficiently close to the solar system to enable us to determine their motions across the line of sight. In the case of the Hyades, in the constellation of Taurus, this has led to an accurate study of the individual stellar motions of the cluster members in space. All the stars in this cluster move in parallel paths so that from the solar system their displacements in the heavens, measured in angular units, appear to converge toward a single point. From this apparent convergence it is possible to determine the distance of the cluster and even the spread of the stars in different directions within the cluster. As a rule, the galactic clusters are not large objects — their diameters are of the order of about 30 light-years.

Several years ago an interesting feature was found in the Double Cluster of Perseus. This famous object is easily seen with the naked eye between the stars Eta Persei and Delta Cassiopeiae. With a telescope of short focal ratio its appearance is similar to that in Fig. 1, which was obtained by E. E. Barnard with the 10-inch Bruce telescope of the Yerkes Observatory. There are two fairly compact groups of stars, each occupying an area of approximately ¼

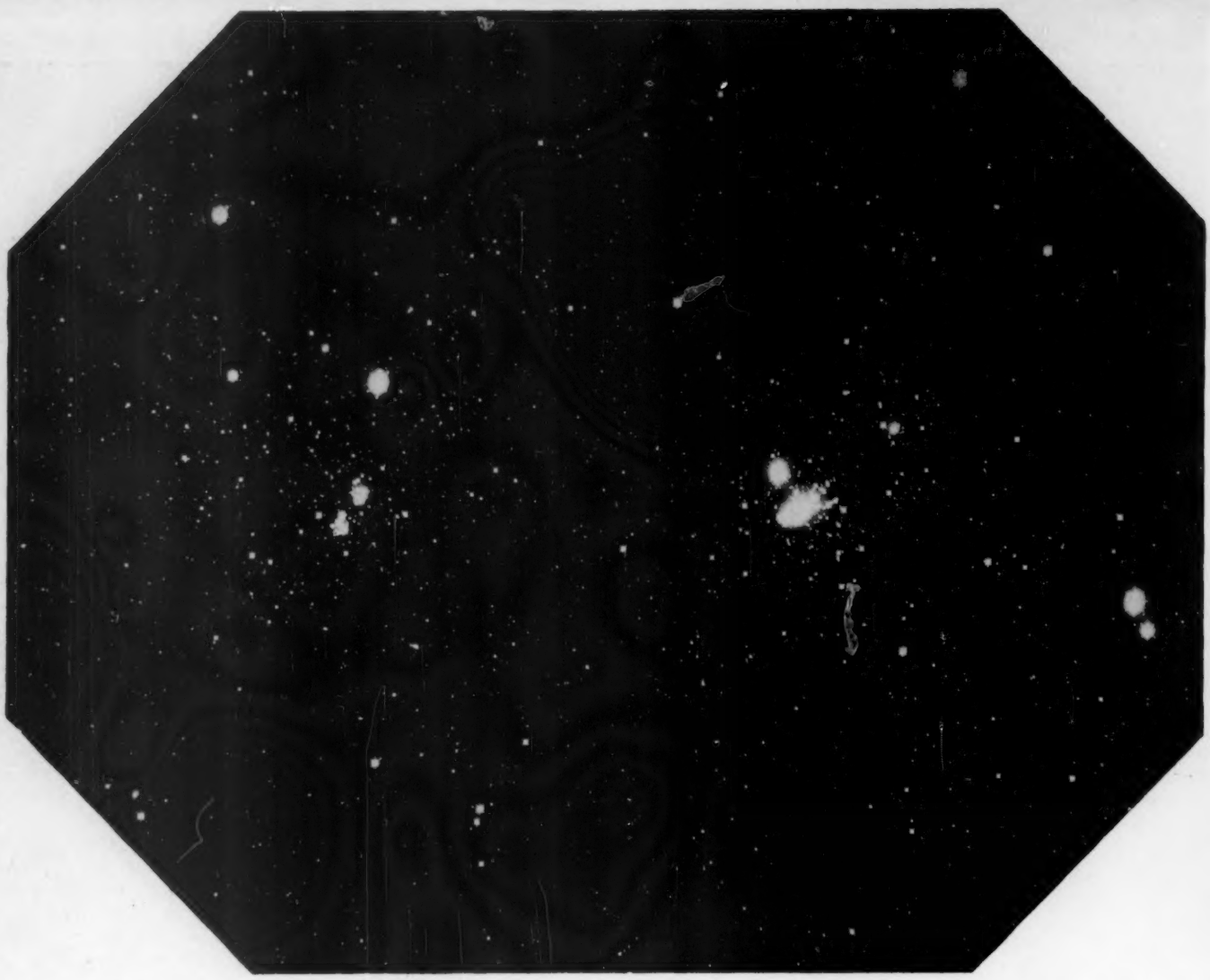


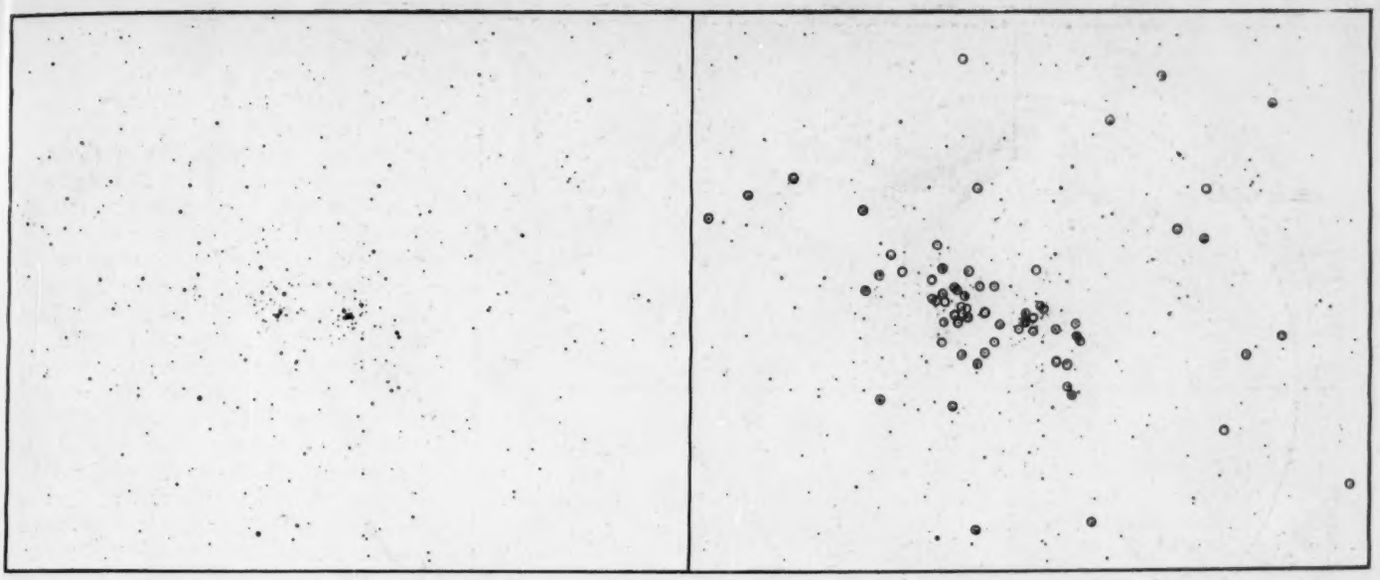
Fig. 2. As reproduced here, the scale of this picture of the Double Cluster is about five times that of Fig. 1. The photograph is by F. E. Ross with the 60-inch reflector at Mount Wilson Observatory, exposure one hour, 40 minutes, with a zero correcting lens used to flatten the field and improve the images.

square degree. From the spectral types of the brighter stars and from their radial velocities we estimate that the distance of the Double Cluster is approximately 5,000 light-years. If the apparent radius of each cluster is ½ degree, this would correspond to approximately 40 light-years in linear units.

With a large reflector the Double Cluster is much less conspicuous. In Fig. 2, obtained by F. E. Ross with the 60-inch reflector of the Mount Wilson Observatory, the size of each grouping is so large that we are unable to appreciate the great density of the stars within each cluster. But the most interesting feature of the Double Cluster is that it appears to be surrounded by a much more widely scattered grouping of early-type stars and a few red supergiants. Fig. 3a represents a negative of the cluster taken with a somewhat larger telescope than was used in the case of Fig. 1 and with a relatively short exposure, in order to show only the brighter stars. Fig. 3b shows the same field with circles marking those stars which, according to W. P. Bidelman, belong to the cluster. These stars are all supergiants and giants of spectral classes *B*, *A*, and *M*. A few additional stars are outside the limits of the photograph. There is a general tendency for these stars to be concentrated toward the clusters. Around the latter is this spherical distribution of supergiant stars which bears little resemblance to an ordinary galactic cluster. As a matter of fact, the star density of the cluster members beyond the limits of the Double Cluster itself is much smaller than the star density of the Milky Way field on the plate. This outer portion of the cluster could not have been discovered simply by the inspection of photographs. The few cluster members blend so completely into the background of the Milky Way that it is not possible to distinguish them by statistical means.

Nevertheless, their connection with the Double Cluster is beyond doubt. They have the same radial velocities, the same interstellar calcium lines, and the same distance moduli, by which we mean the quantities $m-M$, where m is the apparent magnitude and M is the absolute magnitude. Bidelman has reached the conclusion that this group of high-luminosity stars associated with the Double Cluster in Perseus extends over approximately 450 light-years. There is no doubt about the connection of this large group of small star density with the central double cluster of high star density. According to the observations at Yerkes and McDonald Observatories, the extended group includes 46 supergiant and giant stars of spectral classes *B* and *A* and of visual absolute magnitudes ranging between -7 and -4. There are at least 13 supergiant stars of spectral class *M*, most of which are irregular variables whose visual absolute magnitudes are about -5. There are also some fainter stars of spectral classes *B*1 to *B*3 that have hydrogen emission lines in their spectra. Apparently the cluster contains no supergiant stars of classes *F*, *G*, or *K*.

The extraordinary size of this outer cluster and its remarkably low star density raise the problem of the stability of such groupings of stars. Many years ago B. J. Bok investigated the manner in which a star cluster is gradually disrupted by the effect of galactic rotation. More recently, Chandrasekhar has discussed the rate of disintegration of clusters by the escape of stars and by the tidal forces of the entire Milky Way. The time of relaxation of a galactic star



Figs. 3a (left) and 3b. The brighter stars in the Double Cluster field include giants and supergiants that are members of the cluster.

cluster is short compared to the age of the galaxy. For example, an average cluster may be disrupted in about 30 million years, which is comparable to the age of a very luminous star as determined from the rate of conversion of its hydrogen into helium. In the most luminous supergiants this latter process proceeds approximately a million times faster than it does in the sun. But Chandrasekhar's computations refer specifically to the relatively dense central portions of a cluster, such as of the Pleiades or the Double Cluster in Perseus. The vast stellar associations which surround some of these more compact groups are even more vulnerable to the effect of tidal forces of the galaxy and to the disturbing action of other stars in their vicinities.

In a remarkable paper which has just appeared in the *Astronomical Journal* of the Soviet Union, V. A. Ambarzumian has again called attention to these large stellar associations. He has found a number of new groupings of the same kind. Most of them consist of stars of early spectral type. It has been known for many years that the *B*-type stars have a tendency to form large clouds of stars which are all approximately at the same distance from us. One group of this kind is associated with the large star cloud in Cygnus. A plot of the *B*-type stars, not later than *B*3, in the region of Cygnus is shown in Fig. 4. An even more striking presentation of the separate clouds of *B*-type stars in the Milky Way was published in 1929 by A. Pannekoek. This is reproduced in Fig. 5. Since the work of Pannekoek some of the distances have been changed, but the general tendency of the hotter stars to appear in clouds, or in what Ambarzumian calls stellar associations, is as conspicuous, or perhaps even more so, than we thought it to be 20 years ago.

As a rule these associations of early-type stars have radii of the order of 500 light-years. The star densities are small, not only when observed in projection on the background of the Milky Way, where the members of these groupings blend with the background structure of our stellar system, but they are small even when counted per unit of space. This is true, however, only if we disregard the physical differences between the stars. If we examine only those stars that belong to early spectral types, we find that the densities in the stellar associations greatly exceed those of similar stars elsewhere.

One very interesting conclusion that results from the recognition of these peculiar groupings is that from a distant spiral nebula the association would appear as a distinct cluster easily seen on the background of our Milky Way. The reason for this is that on our own photographs, taken from within the Milky Way, the intrinsically faint stars that are close to us appear projected upon the field of the stellar association, thereby producing the appearance of a uniform field of stars. But from a distant, extragalactic system the intrinsically faint stars of our neighborhood would be completely invisible and only the intrinsically luminous stars would stand out. Thus, the cluster of Perseus, as observed from the Andromeda nebula, M31, would appear to have a diameter of about 450 light-years, and an observer at that distance might never suspect that in the center of this larger cluster there is a much more compact group which is known to us as h and Chi Persei.

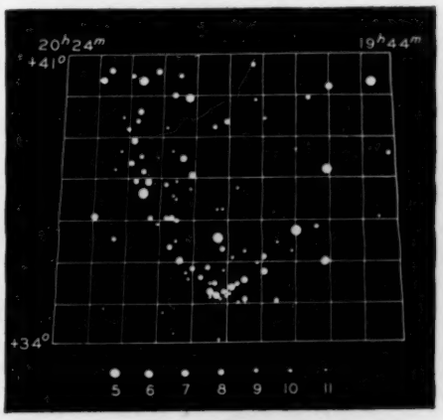


Fig. 4. The distribution of stars of spectral types O to B3 in the Cygnus region. Co-ordinates of right ascension and declination are given, and the scale is of apparent magnitudes.

This result is especially interesting in connection with star clusters that have been found in the Large Magellanic Cloud and in some of the nearer spiral nebulae. For example, the object designated as NGC 1910 in the Large Magellanic Cloud is a group of supergiants containing several stars of the P Cygni type. The diameter of this cluster is roughly 250 light-years, which places it distinctly outside the realm of the ordinary galactic star clusters of the kind of the Hyades and the Pleiades. Shapley has remarked that the frequency distribution of the open clusters in the Large Magellanic Cloud shows two maxima, one for diameters in excess of 60 light-years, and the other for diameters smaller than 60 light-years. This distinction immediately suggests that we have two different types of objects — the more compact galactic clusters and the much more dispersed stellar associations.

Ambarzumian has attempted to relate to these associations several large groups of peculiar dwarf stars that have distinctive features in their spectra. For example, he has called attention to A. H. Joy's group of variable stars of the T Tauri type, which occupy in the sky an area of about 12° by 12°. A somewhat similar group appears to exist in the region of Aquila and Ophiuchus. These stars are all in the same region of space because they are connected with dark clouds of dust and gas, but there is some doubt as to whether they are necessarily

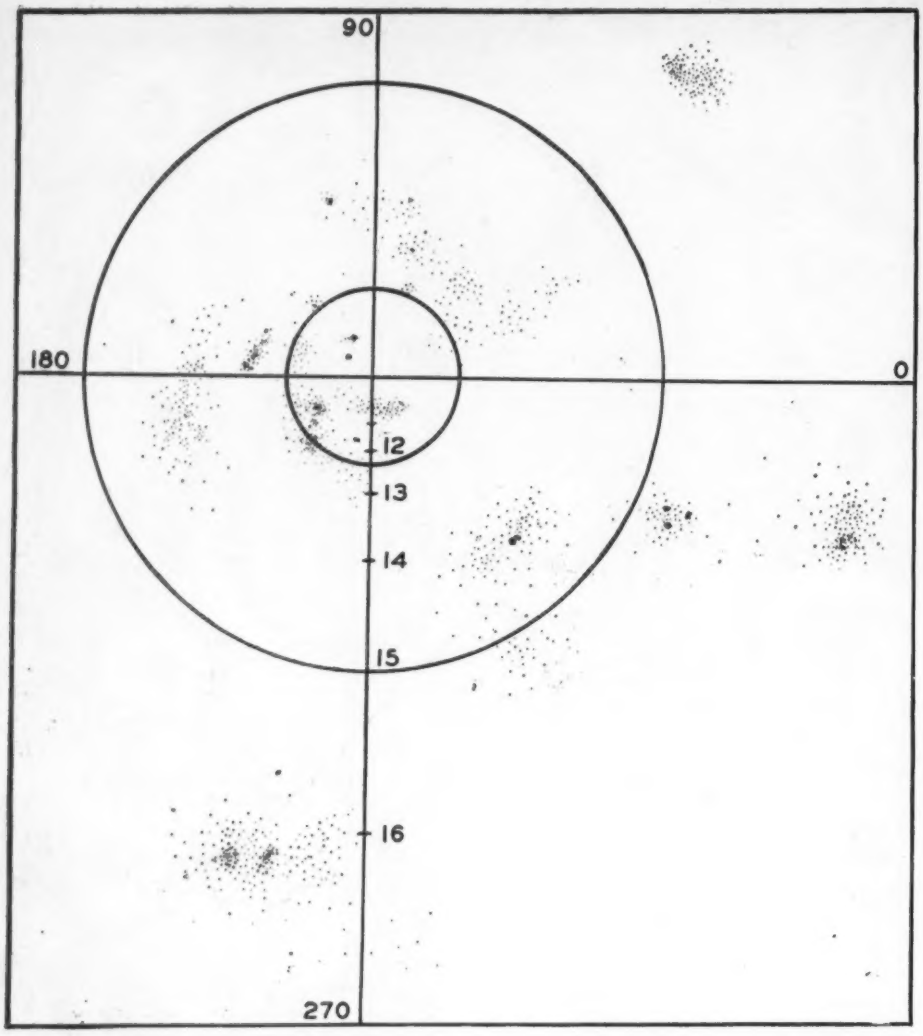


Fig. 5. The groups of type B stars projected on the plane of the galaxy, as derived by A. Pannekoek from the Henry Draper Catalogue. The counterclockwise co-ordinates are galactic longitude; the radial co-ordinate is distance modulus (apparent minus absolute magnitude); the circles indicate distances of 300 and 1,000 parsecs from the sun (as estimated in 1929). From the "Publications" of the Astronomical Institute of the University of Amsterdam.

connected physical systems. If, as seems probable, they have all originated within the dark clouds, then they should probably be regarded as stellar associations; but it is possible that they are simply faint stars which have drifted into the clouds and have been exposed to the infall of meteoric matter which produces their emission lines. If this latter view should prove to be correct, it would not mean that these stars have all the same motions. They may drift into the clouds from different directions and may pass through them, and out of them, at intervals of several million years.

But the true associations of early-type stars and some late-type supergiants are unquestionably real and present an interesting problem of cosmogony. Ambarzumian has shown that the effect of galactic rotation will be to distend a group along the Milky Way in such a manner that it will become elongated to about twice its original radius in an interval of 40 million years. This is a short interval of time compared to the age of the galaxy, and we must therefore conclude that if this process is really fundamentally important the stellar groups must all show a general tendency to be elongated in the plane of the Milky Way. In reality no such elongation is observed. This is rather surprising, because the gravitation of the cluster itself cannot keep it from dispersing. The only remaining possibility is that the associations expand much more rapidly in all directions than would be required in order to show the flattened shapes produced by galactic rotation. Ambarzumian estimates that the velocity of expansion of the stellar associations cannot be less than one kilometer per second, because otherwise the effect of flattening in the plane of the Milky Way would predominate. On the other hand, the expansion cannot exceed 10 kilometers per second, because otherwise the stars would show this effect in their radial velocities. He adopts an expansion of five kilometers per second as the most reasonable compromise and concludes that associations of stars which are now visible should become completely dissolved within the general mass of the stars in the galaxy in intervals of 10 or 20 million years.

If this rather revolutionary view should be substantiated it would mean that the stellar associations of the type of the one surrounding the Double Cluster in Perseus are only about 20 million years old. This would represent at the same time the age of the stars contained within the association, because it is clear that the stars could not have been formed before the expansion began. It is significant that the ages of the most luminous stars within the clusters, such as those of the P Cygni type, the Wolf-Rayet type, or the earliest subdivisions of classes *O* and *B*, are also of the order of 10 to 50 million years. But Ambarzumian's hypothesis makes it necessary to suppose that those stars that we now observe as dwarfs of the later spectral classes are also only about 20 million years of age. These stars do not convert hydrogen into helium at a sufficiently fast rate to change their composition appreciably in less than about one billion years. Hence, if Ambarzumian is right, these later-type dwarfs must have been produced in some as yet unknown manner 20 million years ago. Perhaps they were formed in the beginning with essentially the same physical characteristics as those which we observe at the present time. Another possibility would be that they have been produced out of the early-type giants and supergiants through some other evolutionary process than the conversion of hydrogen into helium.

The number of stellar associations containing early-type stars is not known. Ambarzumian estimates that we can observe one or two dozen such groupings and that, consequently, the total number in the Milky Way may be of the order of 100. If we should be willing to recognize as real stellar associations the groupings of T Tauri stars and other objects of relatively low luminosity, then the total number would probably be several thousand. Since each association can last only a few million years before becoming dissolved in the Milky Way, we must assume that on the average one association of stars is created every 1,000 years.

Each association contains about 100 stars. During the lifetime of the Milky Way about 10 million stellar associations must have passed through their evolutionary cycles, each of them ending in the complete disintegration and the spreading of its members within the general galactic structure. Hence, it is reasonable to suppose that billions of stars which we now observe throughout the galaxy have been, at some time in the past, members of these associations. Perhaps all stars have been formed in this manner.

But what precedes the formation of a stellar association? Apparently, Ambar-

zumian thinks of some kind of explosive process. In some of his earlier papers he has advocated the strange and unconventional idea that the stars may not have been produced of dust and gas, which we now observe in the Milky Way, but that they previously formed dark objects of unknown constitution, whose masses may have been several hundred or even several thousand times the mass of the sun. No such objects can now be observed within our galactic system, and dynamical considerations would make it difficult to assign to them a total mass comparable to that which is now contained in the stars or in the diffuse galactic dust clouds. Nevertheless, there is probably no good reason to deny the possibility of their existence. For example, Ambarzumian supposes that they might have dimensions of the order of ordinary stellar diameters, in which case their large masses would not produce appreciable obscuration in the Milky Way and would not greatly affect the motions of the stars whose proper motions and radial velocities we have measured. Ambarzumian believes that the surface brightnesses of some extragalactic systems give additional cause for believing that they contain masses of an unknown kind, in addition to the stars and diffuse clouds. His arguments are perhaps not very convincing. Nevertheless, they must be taken into account as we attempt to explain the properties of the stellar associations.

ED. NOTE: This is the first article in a regular series that Dr. Struve will write for *Sky and Telescope*, to fill the need for co-ordinated discussion of modern astronomical thoughts and discoveries at a level suitable for astronomically minded readers. "Stellar Associations" is an example of the stimulating manner in which Dr. Struve, one of the world's leading astronomers, may be expected in coming articles to blend established facts and new theories in various fields of astronomy.

TERMINOLOGY TALKS

J. HUGH PRUETT

Sunspots

Consternation aplenty ruled in scholarly circles, both religious and scientific, when in 1613 Galileo announced that his little "optick tube" had revealed sooty spots on the shining countenance of Old Sol. "Impossible!" retorted the skeptics. "Has it not been known since the days of the ancient Aristotle that the sun is a pure body of light without blemish? Spots would destroy its purity, therefore they *do not* exist."

Inasmuch as large spots, when present on the sun, can easily be discerned by viewing the sun through smoke or thin clouds of the proper density to remove glare, and as there were records of just such observations by the Chinese long before Galileo's time, it is somewhat surprising that these 17th-century savants were so disturbed by his observations.

With a small telescope you may easily observe sunspots today, but NEVER look at the sun through an optical instrument without some protective device, or blindness may result. Many observers use a dark eyepiece cap to dull the intense solar image, but this is not safe as the dark glass may crack due to the heat and thus permit serious injury to the observer's eye. A protective covering over the objective or mirror is safe. For years I have used photographic negatives over the objectives of my 7 x 50 Zeiss prism binoculars with excellent results. If the negative is too dense, not much satisfaction is obtained from the view of the sun; if too thin, the observer is bothered by the excessive light. For higher powers, neutral density filters should be better than film, for the latter may somewhat impair image quality.

Special diagonal devices (Herschel wedges) may be used at the eyepiece end of even large telescopes to turn away most of the light in another direction, permitting only a very small percentage to enter the eyepiece. Even then, a dark glass is used over the eyepiece.

The most satisfactory way for small-telescope owners to view sunspots is to project them on a white cardboard screen. The more the screen is shaded — observers crowding around helps — the clearer the picture. The farther the screen is from the eyepiece the larger, but dimmer, is the solar image. As for larger reflectors, I know of an occurrence with a 16-inch in which excessive heat on the secondary ruined it during an attempt to project the solar image. It is common practice to stop down large apertures — a piece of cardboard with a circular hole in it works well.

Umbra and Penumbra

The brilliant spherical surface that seems to be the outside of the sun is known as the photosphere (*sphere of light*). Embedded in this, each well-formed sunspot appears to be composed of two distinct parts: a dark center known as the umbra (*shade*), and a surrounding lighter portion, the penumbra (*almost shade*). These are the same terms as are used in describing the parts of the shadows of the earth and moon.

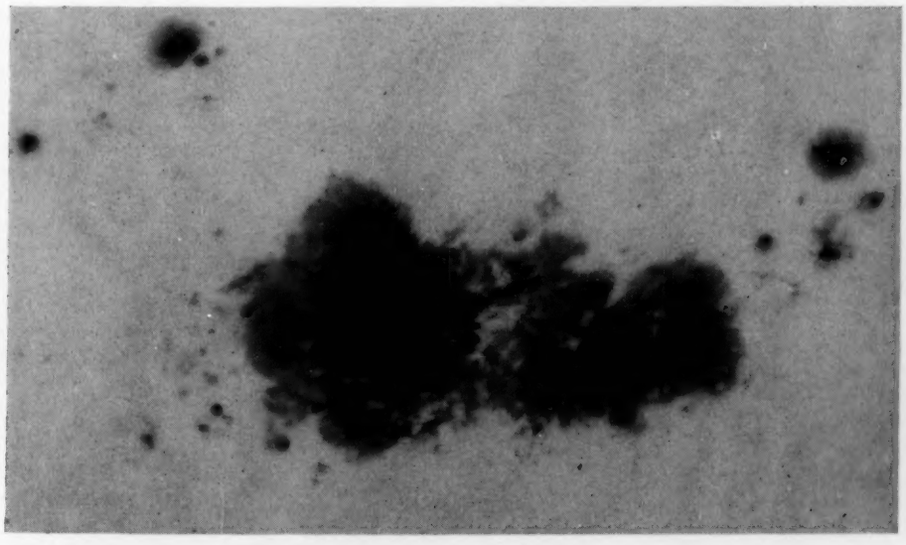
It is known that the umbra is actually very bright, and it looks dark simply by comparison with the brilliant photosphere. The dark sides of Mercury and Venus when seen transiting the sun's disk appear much blacker than the umbrae they seem to pass. The temperature of the photosphere is about 6,000° absolute, while that of a sunspot umbra is "only" about 4,500°. But compare either with the boiling point of water, a mere 100° centigrade or 373° absolute.

An umbra may be barely detectable or it may be nearly 50,000 miles in diameter; a large penumbra may extend over 150,000 miles. The technical method of stating the size of a sunspot is to give its area in millionths of the total area of half the sun's surface. Thus 1,000 means 1,000/1,000,000 of the area of the solar hemisphere.

What Are Sunspots?

Soon after sunspots were discovered it was proposed that they were dark bodies far from the solar surface and merely passing between the earth and the sun. Galileo thought the darkest parts were possibly cinders rising from the solar interior. Around 1800 Sir William Herschel suggested that the main body of the sun, solid and likely cool enough for habitation, was completely surrounded by two separated spheres of cloud. The outer layer was intensely brilliant and fiercely hot, as we see it, while the lower (inner) layer

(Continued on page 221)



The largest single sunspot on record, a penumbral area containing many umbrae, photographed at Mount Wilson Observatory on March 10, 1947. Its area was five billion square miles, and it broke up to form the largest sunspot group known.

Scouts observing stars by day under the author's guidance. Photo by Paul Berlin.

Popularizing Astronomy
With a Portable Observatory

By S. I. Gale, *Lecturer, Hayden Planetarium*

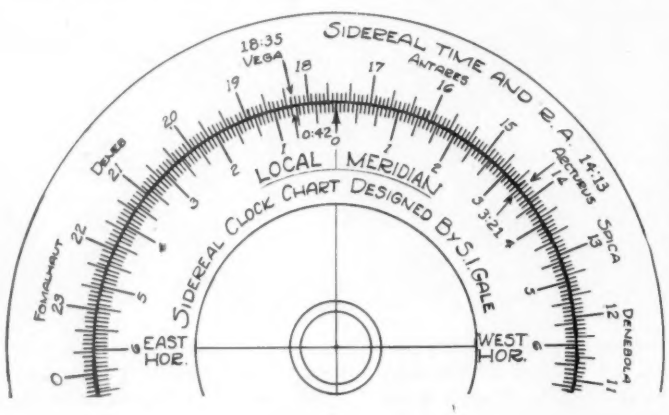
How many amateurs among us have thrilled at the opportunity to transmit to others some small part of our enthusiasm for astronomy? Those who have watched the glistening eyes and the eager faces, those who have been deluged by the flood of searching questions that inevitably accompany popular demonstrations on astronomy, know that there is no gratification quite like it. While many of our friends, cloistered in their back yards, may be content to pursue astronomy as a satisfaction to themselves alone, others of us feel that we can be serving our neighbors in a unique and significant way by fueling the dormant fires of their interest in the geography of our universe. For the amateur who may have seriously wondered just how well a demonstration on astronomy might be received by one of his local clubs, let him be assured that, if his program is carefully prepared, he will meet astonishingly receptive audiences wherever he may venture.

One of the amateur's major concerns is whether his equipment is adequate to the task of illustrating a genuinely informative lecture on astronomy. All too often it is assumed that a lecture can only be justified if it is accompanied by a fabulous array of costly, high-powered equipment, such as that normally available only in fully equipped observatories. Certainly, it would seem, a small portable telescope would be totally unacceptable. However, if such were the case, the public would benefit from very few demonstrations, except possibly in large cities or in towns favored by well-endowed colleges or universities. As a result, the public's need for reliable information regarding astronomy would be almost totally ignored. Although indispensable for those technically trained, a fixed observatory has the basic shortcoming that its usefulness as a means of public education is confined to the area in which it is located. On the other hand, a portable telescope has the singular advantage that it can easily reach large numbers of people anywhere.

Far and away the most serviceable type of telescope is one that is both portable and of fair size. Its construction should be such that it can be set up easily in the field and operated with the aid of setting circles and clock drive. (When an instrument has no circles and no drive, its usefulness in many cases is confined to brief glimpses of bright objects located by means of the finder.) As scores of amateurs will agree, it takes no great ingenuity to build an instrument of this caliber. Yet its advantages are tremendous. It can be taken wherever groups may meet. It can be set up early and used for observations either by day or night. It is a versatile instrument that can make the impact of astronomy so much more forceful, so much more personal than can the smoothest, most factual presentation unaided by the lecturer's own telescope.

Over the past three years, the 8-inch reflector shown here and on the front cover has helped hundreds of boy scouts and girl scouts, as well as many others, to a new, intimate understanding of astronomy. By chance, the original design of this telescope was such that it readily lends itself to field work. The frame, built of 1¼-inch pipe, has a three-point support, six feet on a side, two of the supports being adjustable for leveling on uneven ground. An all-way level is built right into the frame. The telescope mounting has the vitally important feature that it can be folded up easily when not in use.

Of course, one of the major tasks is setting up the telescope properly. First, the frame is roughly oriented north and south with the aid of a K & E forester's compass placed across the north-south axis during alignment. The telescope and its cradle, with a pivot, clutch, and gear drive on one end and a horseshoe bearing on the other, are dropped into place and the level and orientation checked once again. The alignment is finally completed by using setting circles while sighting on the sun. If this procedure is followed carefully, the pos-



The outside of this clock circle rotates around the inside, permitting the observer to read hour angle directly. Settings of the telescope for the examples of Vega and Arcturus are shown in the diagrams on the page opposite.

sible error is usually less than one degree, which is ordinarily accurate enough. With a low-power eyepiece and a one-half degree field of view, a planet or, better yet, a bright star can be readily located by day after only a few minutes of hunting.

For absorbing interest, for intriguing beauty, and for the sheer delight of accomplishment, there is nothing in the experience of the amateur telescope enthusiast quite equal to the thrill of successfully locating, by setting circles, a spring star shining faintly but bravely through the deep blue of the summer sky. With its delicate red glow against the blue, Arcturus has a fascination all its own. Because the two colors contrast so sharply, Arcturus is especially easy to find. Most gratifying of all is the unexpected appeal it has for others. A star by day delights and astonishes. Amazingly enough, it invariably arouses more interest and curiosity than many of the more spectacular objects viewed at night. The lively interest thus generated gives vent to a host of thought-provoking questions —about the nature of the stars, the operation of the telescope, the mechanics of day and night, and innumerable other questions that seldom emerge during night observing. If observers can be made to view the heavens objectively without becoming spellbound in the process — a goal which can easily be attained in daylight scanning — the same all-important objectivity will characterize their approach to the night sky. For many, the experience of daylight observing will completely clear away the underbrush of mystery, fear, and superstition that frequently impedes a really sane approach to astronomy.

During the day, many of the more practical aspects of astronomy can be demonstrated conveniently. Sunrise, sunset, and the seasonal paths of the sun are of universal interest. Sunspots lead to a discussion of the nature of the sun, the origins of magnetic storms, and fluctuations in the weather. These, in turn, can lead to explanations of noon, the local meridian, the significance of the polar axis, right ascension and declination. When there is a sidereal clock handy, such as the one shown in the accompanying photograph, the lecturer's job is vastly simplified.

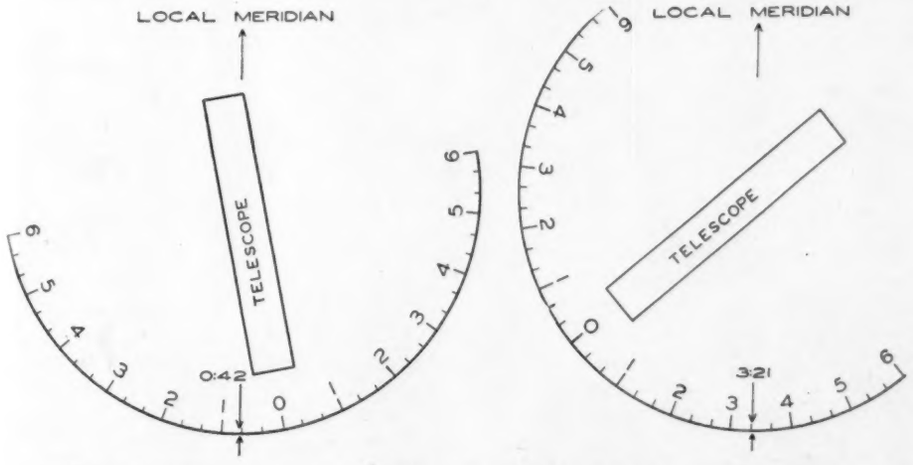
This valuable adjunct to group observing not only keeps star time but, by means of its revolving outer disk and stationary central disk, shows continuously the hour angle of a body with respect to the local meridian. With such a sidereal clock, the hour angle can be read directly without arithmetical calculation and can be transferred to the right-ascension circle on the polar axis of the telescope. Most important for group instruction is the visual-aid feature of the clock. Since the revolving disk carrying the sidereal time past the local meridian is, in reality, a miniature working model of the plane of the celestial equator, traveling westward in imitation of the sky, the mechanism of right ascension becomes immediately self-evident. Youngsters who a short time before could not distinguish the polar axis from the vernal equinox understand this aspect of astronomy almost at once, and they are not only able to explain it to others but are actually capable of setting the telescope.

The sidereal finder clock itself may be made by modifying a spring-wound recording thermometer clock, such as that used extensively in the chemical industry. The paper chart is replaced by a plastic right-ascension circle disk which travels around a stationary inner circle carrying the local meridian and hour-angle scales on each side. The regulator is adjusted to permit the clock to keep pace with sidereal time. To give a clockwise direction to the travel of the outer disk, the clock must be used upside down. The clock drive for the telescope is provided by a small synchronous electric motor geared to the outer end of the polar axis. The electric current is supplied through a 300- to 400-foot cable running from a nearby

The northern end of the yoke of the author's 8-inch reflector is horseshoe shaped, to permit observations of Polaris. The sidereal finder clock is at the center of the chart table. Photo by Paul Berlin.

building. This cable also furnishes the current necessary for lighting the clock and setting circles for night observing. Of course, phonograph-motor drives or other nonelectrical devices may be used to drive the telescope in right ascension.

For all amateurs who sincerely wish to make a contribution to astronomy and have a good time doing it, the horizons are truly limitless. First of all, provide yourself with the right equipment. Take your telescope to the places where the most people gather. Then observe the sky throughout the day, across the threshold of evening, and far into the night. For you, the rewards will be a host of new friends and the delight that comes only from enriching the lives of others. For all, the sky will reveal a few more of its secrets.



How the telescope tube is set with reference to the local meridian for Vega (left) and Arcturus (right) from readings on the inner dial opposite.

TERMINOLOGY TALKS

(Continued from page 219)

was nonluminous and served to shield the solar inhabitants from bodily discomfort. At times, so Herschel surmised, there occurred breaks in both spheres, thus permitting earth dwellers to see dark spots of the sun's surface often seemingly surrounded by a lighter border of the lower cloud layer.

Present-day astronomers still find much of mystery in sunspots. There is good reason to believe that they are caused by vast masses of luminous gas boiling up from the solar depths and cooling by expansion. At the visible surface — or below it — the gases seem to spiral outward from the region of a spot and to produce magnetic effects.

NEWS NOTES

By Dorrit Hoffleit

TEN YEARS AT McDONALD

With the completion of the first decade of observations with the 82-inch telescope on Mt. Locke, near Fort Davis, Tex., Dorothy Hinds and Gerard P. Kuiper have published in *Popular Astronomy* some statistics on observing hours and weather conditions. Exact records have been kept since March 1, 1939, of all hours when the telescope was in operation and for what type of work. Spectrographic observations occupied 84 per cent of the working time, direct photographs and micrometer work seven per cent each, and photometry two per cent (carried on in 1947 and 1948 only). For the last year, these percentages were 61, 10, 16, and 13, respectively.

If maximum working time is defined as the interval between a half hour after civil twilight and a half hour before civil dawn, the telescope was in operation on an average of 65.4 per cent of this time, with only minor variations with the seasons. In August, 1943, working time was 91 per cent of the total nighttime hours, but in August, 1942, only 33 per cent. The average rainfall of 20 inches a year falls mostly from May to October, but much of it is in the daytime and does not affect the night skies. For programs requiring fairly uniform distribution of observations throughout the year the McDonald weather is definitely advantageous.

TINY MAGNETS IN SPACE

A short time ago W. A. Hiltner and John Hall found that starlight is plane-polarized (*Sky and Telescope,* April, 1949, page 142). The degree of the polarization might be explained, according to Lyman Spitzer, Jr., and John W. Tukey, of Princeton University, if needle-shaped particles comparable in size with the wave lengths of visible light were present in interstellar space and were oriented by some force. The two difficulties with this suggestion, the authors point out in *Science,* May 6, 1949, are to account for the origin of the needles and for their orientation.

"If we accept as a working hypothesis: (1) the existence of small ferromagnetic particles, which, existing as individual domains, are intensely magnetic; and (2) the existence of magnetic fields in interstellar space with systematic components as great as 10^{-5} gauss; then these difficulties disappear."

The first of their hypotheses appears reasonable on the basis of recent theories on the origin and growth of interstellar grains, while the second is consistent with work by Fermi on the origin of cosmic rays. Furthermore, the ratio of the number of oriented ferromagnetic needles to the number of unoriented grains of similar size need be only a fraction of one per cent in order to explain the observed polarizations of starlight. Much research still needs to be done on the chemistry of fusion and on the subsequent magnetic and optical properties of grains in interstellar space before the suggestions offered can be regarded as more than a working hypothesis, the authors warn. However, should further research confirm the picture, "it may become possible to obtain direct experimental evidence on the magnitudes and directions of magnetic fields in interstellar space."

FIRST NEW COMET

This is a slow year getting started for comets. The first new comet discovered this year was found on May 20th by E. L. Johnson, of the Union Observatory at Johannesburg, South Africa. A 13th-magnitude object at discovery, the comet was in the constellation Lupus, too far south for most North American telescopes. Mr. Johnson has two previous comet discoveries to his credit. In January, 1935, he discovered the first comet of that year, and he found another faint one in September, 1948. By this time last year five new comets had already been discovered, two in January, two in March, and one in early June.

SOUNDING THE OZONOSPHERE

The ozonosphere, that layer of the atmosphere lying mostly between 100,000 and 150,000 feet above the earth's surface, is being explored by radiosonde balloons developed by the Army Signal Corps. Standard sounding balloons used for meteorological purposes weigh about five pounds and burst at about 100,000 feet, whereas the new balloons weigh about 17 pounds, and expand to diameters of 75 feet by the time they have attained 140,000 feet. On September 28, 1948, in a record-breaking ascent, a balloon required 2½ hours to reach that altitude. It disappeared in clouds at 40,000 feet, but was tracked by radio. On July 8th a similar balloon was visible to the naked eye at an altitude of 120,000 feet.

In the June *Scientific Monthly,* Dr. C. J. Brasefield, of the Signal Corps Engineering Laboratories, describes the ozonosphere equipment at Evans Signal Laboratory, and gives data on September 28th weather conditions at various altitudes. The temperature fell to a minimum of —71° centigrade at 50,000 feet, then rose to —22° at 133,000 feet. Winds were generally westerly, with a maximum speed of 94 miles per hour at 40,000 feet, but were easterly above 60,000 feet on earlier flights during last summer and fall, when a total of 20 balloons was released in these experiments.

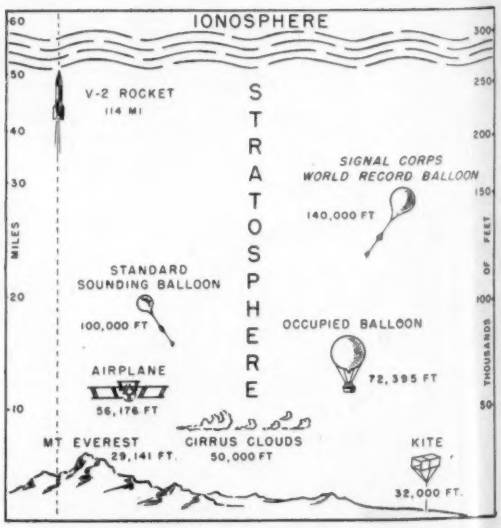
Ultraviolet absorption by atmospheric ozone is so strong that most solar ultraviolet radiation is absorbed at about 200,000 feet, where a maximum temperature of the air is expected. It has been suggested that the missing links between solar activity and weather data might be found in the ozonosphere.

ACHONDRITIC SHOWER

Fourth among the astronomical highlights of 1948 listed by Dr. Harlow Shapley (*Sky and Telescope,* December, 1948, page 42) is the recovery of the Norton meteorite fall of February 18, 1948, including an achondritic mass weighing over a ton: the largest specimen of the most fragile known variety of meteorite. A long-awaited account of this rare type of fall, by Dr. Lincoln La Paz, of the Institute of Meteoritics, University of New Mexico, has appeared in the April *Publications* of the Astronomical Society of the Pacific.

Many fragments of the fall have been recovered within the bounds of four townships of Norton County, Kans., and one in Furnas County, Nebr. The time of year of the fall, when snows repeatedly covered the ground, was inauspicious for the discovery of meteorites. Later, on May 1st, when a 14-year-old youth discovered a deeply buried achondrite weighing over 130 pounds, it was rightly hailed as a giant of its type. On July 3rd, the 2,000-pound mass was likewise found in an area previously searched. It lay in a six-foot crater in a field so overgrown with weeds and stubble it evaded detection until "by chance a caterpillar tractor started to fall into it."

In closing his discussion, Dr. La Paz points out that the meteorite came to earth under conditions very favorable to the survival of recoverable meteorites



The present state of balloon exploration of the earth's atmosphere, from a diagram by the Army Signal Corps.

— its estimated geocentric velocity was only 5.75 miles a second. Otherwise, so fragile a material could not have survived its passage through the atmosphere. It has been observed by meteoriticists of the past that the latter half of the month of February has been notable for fireballs of marked brilliance; yet the same month is equally noted for the absence of meteorite falls.

"This curious anomaly between the number of exceptionally bright, often detonating, February fireballs and the rarity of actual *meteorite* falls in this month may find its explanation," writes Dr. La Paz, "in relatively frequent encounters during this month between the earth and achondrites like those recovered from the fall of February 18, 1948. Meteorites of such composition and structure, although large enough to produce spectacular light and sound effects in the intermediate layers of the atmosphere, might disintegrate so completely during transit through the denser lower atmosphere that only dust would survive to reach the earth."

ASTRONOMY COVERS EVERYTHING

The annual report of the director of the Princeton University Observatory includes a subtopic, "Social Physics." It reports that astronomer John Q. Stewart "is continuing his path-breaking research in the interpretation of economic and social statistics. He has shown that the population potential in a region, defined as the sum of a country's population divided by the harmonic mean distance of this population from the region in question, apparently determines many of the properties of the region, including rent, percentage of rural non-farm to rural farm population, birth rate, etc."

THE ATOMIC CLOCK

For many years, at the United States Naval Observatory and other national observatories where time is recorded and dispensed, quartz-crystal-controlled clocks have been used to keep time as accurately as does the earth itself — to about 1/1,000 of a second per day. Nevertheless, quartz-crystal clocks are subject to vagaries that have indicated the need for even more accurate means of control. This has now been found in what is known as the "atomic clock," developed at the National Bureau of Standards by Dr. Harold Lyons and members of the staff of the bureau's microwave research laboratory.

The frequency of an absorption line produced in the microwave (very short radio wave) region of the spectrum by ammonia gas under a pressure of 10 or 15 microns is now used as the "governor" on apparatus capable of time constancy of one part in 10 million, with a theoretical potential accuracy of one part in a billion or more. If the microwave signal output of a quartz-controlled frequency generator differs in frequency from that of the ammonia absorption line, the control circuits generate an error signal which brings the microwave signal back to the frequency of the spectrum line.

In addition to its obvious astronomical applications, such as furnishing an invariant check of the earth's rotation, the atomic clock will prove invaluable in many fields. It will provide room for more stations in the radio broadcast spectrum, as station transmitter frequencies can be maintained to very close tolerances. It will aid all radar operations and navigation systems that depend on radio, and will assist in basic research in microwave spectroscopy and molecular structure.

Sir Harold Spencer Jones (right) and Dr. Brian O'Brien, at the Institute of Optics of the University of Rochester, April 12, 1949. Photo by Vincent G. Lisenti.

ASTRONOMER ROYAL PROCURES 98-INCH DISK

Late in March, when Sir Harold Spencer Jones was visiting the University of Michigan Observatory at Ann Arbor, arrangements were completed whereby the McGregor Fund of the University of Michigan donated a 98-inch pyrex telescope mirror blank to the Royal Greenwich Observatory. Together with a 26.5-inch secondary, the mirror will provide the optics for England's projected Isaac Newton telescope, to be erected at the Royal Observatory's new site at Hurstmonceux, England.

These disks were made at Corning Glass Works after the 200-inch mirror blank was successfully cast, at which time the late Heber D. Curtis was planning a large reflector for the University of Michigan. Further funds were not available, however, and now Michigan astronomers are occupied with constructing a new Schmidt-type telescope. Transferring the large mirror disk to England puts it to final good use and solves one of the more serious problems facing English astronomers in planning the Isaac Newton memorial.

The largest telescopes outside the United States at the present time are both 74-inch reflectors, one at Victoria, B. C., at the Dominion Astrophysical Observatory, and one at Pretoria, South Africa, in the Radcliffe Observatory.

The Astronomer Royal left this country for home on April 29th after a three-months tour of the United States, during which time he gave about 45 lectures. His largest audience was in San Francisco, when he received the Catherine Wolfe Bruce gold medal from the Astronomical Society of the Pacific. A rough estimate of his total audience during the tour is 15,000.

ATOMIC ENERGY LEVELS

For more than a year the National Bureau of Standards has been compiling data for tables of atomic energy levels. As Dr. Charlotte Moore Sitterly reports, this entails a complete survey of not only all published results but also all that can possibly be completed in the near future — a survey that has proved eminently profitable. The first volume of *Atomic Energy Levels* is now in press and includes 205 of the possible 276 atomic and ionic spectra for the 23 elements from hydrogen to vanadium.

In anticipation of future astrophysical needs, Mrs. Sitterly is planning an ultraviolet extension of the *Revised Multiplet Table,* to include ultraviolet lines important in the study of forbidden lines (compiled in collaboration with I. S. Bowen), and multiplets that are needed to interpret rocket ultraviolet solar spectra.

SOLAR X-RAYS

Scientists at the Naval Research Laboratory at Anacostia, D. C., believe they have discovered solar X-rays high in our atmosphere. In experiments with V-2 rockets the X-rays were detected by their effects on photographic films covered by thin aluminum and beryllium windows that were transparent to such short wave lengths. Ultraviolet light of wave lengths shorter than 1300 angstroms, usually stopped by air, has also been detected at high altitudes by its effect upon phosphor strips.

Amateur Astronomers

Variable Star Observers Hold Spring Meeting

OBSERVING STARS in the daytime was one of the subjects discussed by amateurs at the spring meeting of the American Association of Variable Star Observers, held at Brown University on May 28th. Three members of the Providence Skyscrapers described their experiences in searching for and seeing stars in the daytime, Miss Wilhelmina Hull without optical aid, Elmer C. Hornby with a small telescope, and Miss Elsie Ridings with the 12-inch refractor of Ladd Observatory.

The principal lecture of the morning was by Dr. L. C. Riggs, of the psychology department of Brown, who spoke on color vision. His explanations of some of the physical and physiological reasons for the eye seeing color as it does were of particular interest to amateur astronomers. Another presentation in which color played an important part was of a series of Kodachromes of the April lunar eclipse, made and shown by F. W. Hoffman. As impressions of the eclipse had varied greatly with the individual observer and with local weather conditions, and as press reports had differed also, the discussion was lively. Those present were in general agreement that the eclipse was not unusually dark, and Dr. Charles H. Smiley, director of Ladd Observatory and host astronomer, pointed out that the moon was near perigee during the eclipse and therefore a dark eclipse was normal for such a deep penetration into the earth's shadow.

Several other short papers in the morning session led up to Recorder Leon Campbell's "Notes on the AAVSO Variables," an interim report to bring everyone up to date on the current status of variable stars under regular observation. A large diagram of SS Cygni was impressive in its length and completeness, presenting an unbroken series of maxima observed for more than half a century.

As has been the recent custom, practically an entire session was devoted to papers related to the sun, a variable star of particular interest to members of the AAVSO solar division. Dr. W. L. Moore, of the University of Louisville, described a method of projecting the solar image on a Willson hemisphere to keep a continuous record of spot activity on the hemisphere. Sunspot statistics of the past 200 years have been analyzed by Carlos Gartiz-Mata. He concludes that the variation in periodicity of the sunspot cycle is due to the shifting of a single periodicity, and by starting at a point partway up the ascending portion of the sunspot-cycle curve he has arrived at an average period of 11.3709 years.

Late in the afternoon the amateurs adjourned to the Seagrave Observatory, where inspection of the equipment and solar observing was followed by a picnic supper and a showing of the color film, The Story of Palomar.

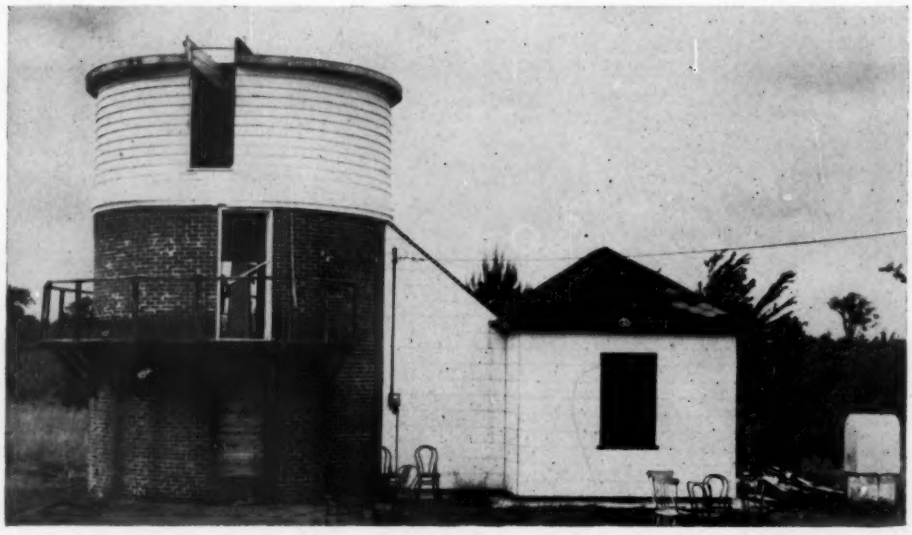
Gathered on the steps of Faunce House Theater of Brown University are members and guests of the AAVSO and the Skyscrapers, Rhode Island amateur astronomers society. Photographs by the editor.

Western Convention at Los Angeles in August

THE LOS ANGELES Astronomical Society is sponsoring the first annual western convention of amateur astronomers, to be held in Los Angeles, Calif., on August 22, 23, and 24, 1949, at the University of Southern California. The first two days of the convention will be held in Los Angeles, the last day at the Mount Wilson Observatory. Registration of delegates is to be in the forenoon of Monday, the 22nd, with the formal opening of the convention in the afternoon. That evening the Griffith Observatory and Planetarium will present a special program for the convention. There will be two sessions for papers on Tuesday, with the convention banquet in the evening. A telescope contest, an exhibit, round-table discussions of observing and telescope making are but a few of the activities planned. Outstanding professional astronomers will address the convention.

This convention is expected to be of especial interest to amateur astronomers everywhere, and all are cordially invited to attend and participate in the presentation and discussion of papers. For further information address the undersigned, program chairman for the convention.

T. R. CAVE, JR.
265 Roswell Ave.
Long Beach 3, Calif.



At North Scituate, about 11 miles from the city of Providence, R. I., is located the Seagrave Memorial Observatory, owned by the Skyscrapers society. The principal dome houses an 8-inch Clark refractor.

ASTRONOMICAL LEAGUE NOTES

Convention plans remain virtually unchanged from the announcements in the May and June issues of **Sky and Telescope.** Dates for the national convention are July 2nd through 4th, at the Case Institute of Technology, Cleveland, Ohio.

The latest group to make application for membership is the Cleveland Astronomical Society, which brings the total membership to 46 organizations, including two in Latin America and two junior groups.

Instead of as announced in June, emblem designs should be sent to Willard A. MacCalla, 634 Rock Springs Road, Pittsburgh 16, Pa. E. S. Hider, chairman of the committee, has moved to St. Paul, Minn., and does not have a permanent mailing address at present.

The annual convention of the Nothwest region of the league will be held at Portland, Ore., on September 3-4, Labor Day weekend, according to an announcement made recently by James H. Karle, chairman of the Northwest region. All amateurs in the northwest or visiting there are invited to attend this convention, for which program details will be available later.

INDIANA TECHNICAL SECTION

A technical section of the Indiana Astronomical Society has been organized, under the direction of Walter Wilkins. Members especially interested in telescope making and advanced observing procedures are invited to register with William Garnatz, 2506 S. East St., Indianapolis, Ind.

AMATEUR TELESCOPE CLUB OF DENVER

In March this year, the Amateur Telescope Club of Denver was formed by a group of amateur astronomers and telescope makers. We would like to affiliate with the Astronomical League, and would be grateful for information from other societies on how to build up our club. We want to gather enough money for a clubhouse, library, machine shop, laboratory, and eventually an observatory.

We have about 10 senior members and about a dozen junior members. Our president is Ray Kramer, and our secretary is Willard E. Johnson, 264 S. Gilpin St., Denver, Colo., with whom anyone interested in joining our group should communicate. We meet the second and fourth Mondays, at the Chamberlin Observatory, Denver University.

ROBERT S. SPALDING
310 Colorado Blvd.
Denver 7, Colo.

AMATEUR GROUP IN NEW JERSEY

On May 2, 1949, at Boro Hall, Roselle Park, N. J., amateur astronomers organized an amateur society for Union County. Talks on the solar system were heard at that and at their June meeting. All interested persons in the vicinity are invited to join the group. Information may be obtained from R. H. Lummis, 63 Westfield Ave., Roselle Park, N. J.

Ralph F. Davis observed a vertical smoke trail immediately after the meteor flashed, but 10 minutes later, when his wife took this picture, the zig-zag train had become nearly horizontal.

TRAIN-LEAVING FIREBALL OVER FLORIDA

ON SUNDAY, June 5th, shortly before 8 o'clock Eastern standard time and not long after sunset, the inhabitants of Florida and parts of Georgia were startled by a brilliant meteor that illuminated the sky brightly and then left a trail of smoke that remained visible to some observers as long as an hour and a half.

At Sarasota, Mrs. Ralph F. Davis took the above picture, and from the same city W. S. Telford sent some newspaper clippings. Reports at present available are sketchy, but they seem to indicate that the meteorite may have fallen into the Gulf of Mexico, so that a search for fragments would go unrewarded. So little is reported of the fireball's apparent path in the sky, however, that this point cannot be decided until more reliable observations are received. All persons who may have seen the fireball should send estimates of beginning and end point positions to the American Meteor Society, Flower Observatory, Upper Darby, Pa., to the attention of Dr. C. P. Olivier.

The meteor was seen from points as widely separated as Brunswick, Ga., on the Atlantic Coast, and Ft. Myers and Miami, in southern Florida. It was observed at Clearwater, Daytona Beach, Fernandina, Jacksonville, Ocala, Orlando, and Tallahassee. Weather Bureau observers at Miami reported that it lit up the sky to the northwest and fell vertically, leaving a luminous, weaving trail that later became almost horizontal, as if blown by high-altitude winds. From Ft. Myers the direction was northwest, toward Cedar Key; and the meteor was also northwest of Sarasota, out over the Gulf from Dunedin. Reports from possible observers in other Gulf states would therefore be of considerable value in determining its actual path.

THIS MONTH'S MEETINGS

Chicago, Ill.: The Burnham Astronomical Society will meet for its annual observation party and barbeque at the home of Mr. and Mrs. Homer C. Torreyson, Prospect Heights, Mount Prospect, on July 30th at 8:00 p.m. There will be about 10 telescopes, member owned, available to members and visitors.

Cleveland, Ohio: The Astronomical League is holding its 1949 national convention at the physics building of the Case Institute of Technology, on July 2nd to 4th. The Cleveland Astronomical Society is host.

Indianapolis, Ind.: At its meeting in Cropsey Hall on July 3rd at 2:15 p.m., the Indiana Astronomical Society will hear a talk by Emsley W. Johnson, on "The Milky Way and Other Galaxies."

Kalamazoo, Mich.: A pot-luck supper will be held at Wolf Lake Lodge, 12 miles west on Route M-43, by members of the Kalamazoo Amateur Astronomical Association, on July 16th at 6:00 p.m. Max Kester will discuss "Solar Prominences," and McMath-Hulbert Observatory films will be shown.

Los Angeles, Calif.: The Los Angeles Astronomical Society will meet at the Griffith Observatory at 7:45 p.m., July 11th, to hear Dr. Frederick C. Leonard, of UCLA, speak on "Captives from Space."

Stamford, Conn.: At 8 o'clock on July 15th, meeting in the Stamford Museum, the Stamford Amateur Astronomers will hear a fellow member, Mrs. Alexander Hamilton, of Norwalk, describe and illustrate her trips to famous astronomical observatories, including Palomar.

St. Paul, Minn.: The St. Paul Telescope Club will meet in Room 7 of the science building, Macalester College, on July 13th at 7:30 p.m., to hear William D. Morgan discuss "The Theory of Planetary Orbits."

Sixty Majo

Part of the starcloud in Sagittarius, a region very rich in galactic objects, and covering some 200 square degrees of the sky. To the right of upper center are the nebulosities M8 (large) and M20, and high on the left edge is M22 (see picture opposite). In the lower right corner are clusters M6 and M7, with other nearby clusters that may be identified from an atlas of the region. The bow and arrow of the Archer are in this area, but only 2nd-magnitude Epsilon Sagittarii, spectral class A0, photographs well (the star with the halation ring near the bottom of the picture). Above it 1⅝ inches and slightly to the right is Delta, a K0 star whose orange color photographs poorly on the blue-sensitive plate. This also applies to Gamma and Lambda, orange stars of class K0.

NIGHT COMES and we, the watchers, look skyward. At what? What celestial objects are best for unaided vision or for telescopes with apertures of three or four inches? What deep-sky wonders should be included in a balanced visual feast? What 60 should be chosen to represent those innumerable bright spots that stand out in the deep darkness and emptiness which, astronomy reveals, make up almost all of the heavens?

First, let us omit the best-known sights: moon, planets, and Pleiades; also variable stars, because much time is needed for observing them. But let us list the unforgettable Coma Berenices cluster, once tuft of the Lion's tail, but later the lost tresses of a devout queen.

Our scroll should honor also the star-clouds of Cygnus, Scutum (the Gem), and Sagittarius, and the Door Cloud, swinging out from the main mass to end in the little Bull of Poniatowski, which nestles against a shoulder of Ophiuchus. Nor should we forget two black nebulosities, the Coal Sack, near the head of the Northern Cross, and the Pipe, just south of Ophiuchus, at the center of our universe. All of these Milky Way wonders should be observed with unaided vision or with an opera glass.

Milky Way with stars unnumbered,
Merged in clouds of light;
Beauty, mystery, that arches
Round the summer night,
Yours are times that none can fathom,
Spaces none can span;
Light of ages, see in darkness
Your wee watcher, Man.

But if our honor roll is to lengthen, we must use optical aid. Fortunate is the owner of a telescope, regardless of its size. Hipparchus and Ptolemy, greatest ancient astronomers, observed much in the starry sphere, but only with unaided vision. No common skyglass would have been common to them. Yet we share the optical heritage of Galileo and Newton. "Blessed are your eyes ... for many prophets and righteous men desired to see the things that you see and saw them not."

Equipped with small telescopes, let us look more deeply into what Sir James Jeans called the universe around us. At what? Certainly no two sky hunters would add to our list exactly the same objects The results would vary because each hobbyist would be influenced by his own experience and preferences. Ought we to select the largest, brightest, best situated, or the most picturesque? Should historical memories sway us? All of these values would be important, but not all could apply in each case.

Yet in every list would appear M31, the great spiral in Andromeda, and probably M33, face-on galaxy in Triangulum, both members of the cosmic group of galaxies containing our own Milky Way. Oddly, they are equidistant from Beta Andromedae and on a line passing through that star. Also included would be three great globulars, M13 in Hercules (most popular, discovered by comet-man Halley in 1714), M5 in Serpens (largest far-north specimen), and the great M22 (first observed in 1665), above the handle of the Little Milk Dipper in Sagittarius.

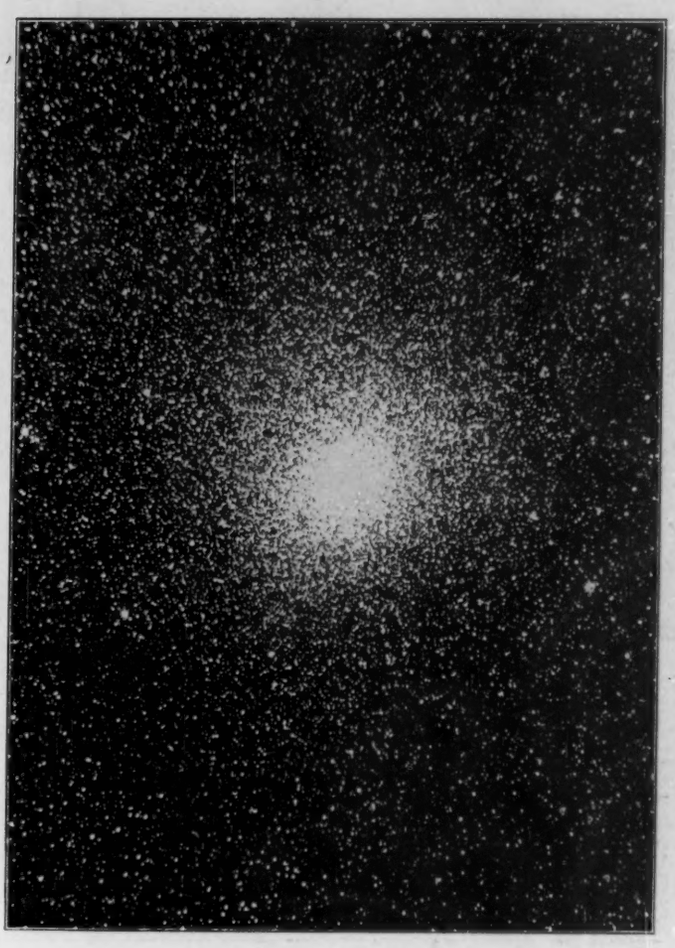
From open clusters would be chosen M44, the Beehive at the heart of Cancer; h and Chi, the Double Cluster, between Perseus and Cassiopeia; and perhaps M6 and M7, above the Scorpion's tail tip. The first two were seen by Hipparchus, 2nd century B.C. And of bright nebulosities would be selected M42, the Great Nebula in Orion's sword and M8, the Lagoon, in Sagittarius, near the winter solstice.

Though unaided but especially keen eyes, straining through dark, clear atmosphere, might discern faintly all of the foregoing telescopic marvels, only reflectors or refractors can yield satisfactory views. Next, looking into our eyepieces, let us find and enroll dimmer denizens of the night sky until we have at least 60 entries.

From the more than 100 planetaries we shall choose the large and handsome Dumbbell, M27, in Vulpecula; the Crab, M1, dimly lurking between the horn-tips of Taurus; the Ring, M57, in Lyra; and the Owl, M97, under the bowl of the Big Dipper. Also the Helical, NGC 7293, the largest, in the great open spaces of southern Aquarius, hard to see because very faint. If it is too

Marvels of the Sky

L. S. COPELAND



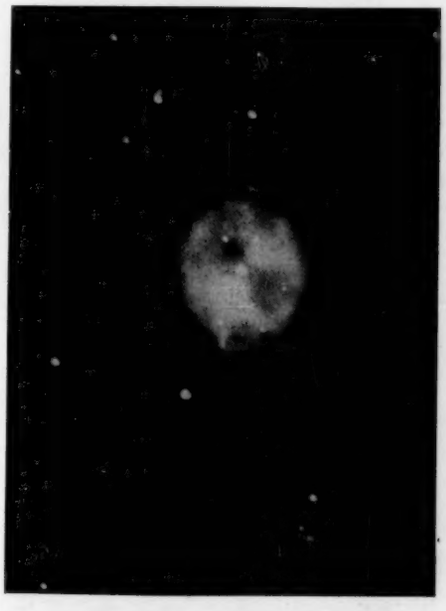
One of the nearest and brightest of the globular clusters, M22, in Sagittarius, in an exposure that reveals the enormous numbers of bright stars comprising a globular cluster. This is a Mount Wilson Observatory photograph. On the picture of the Sagittarius region opposite, M22 appears as a bright spot nearly five inches from the right side and 4½ inches from the bottom.

difficult, substitute M76, the Little Dumbbell, in northwestern Perseus. All of these are awesome, for in some cases they seem to be remnants of stellar explosions.

From the over 100 globulars in our own galaxy, almost all within the reach of smaller telescopes, pick M92, above the Keystone in Hercules; M3 in Canes Venatici, about halfway between Cor Caroli and Arcturus; M12 in west-central Ophiuchus; M55, east of the Little Milk Dipper in Sagittarius; and M4, near Antares, heart of the Scorpion. Depending on your latitude, include or omit the great Omega Centauri, near the southern horizon or below it for observers in the northern United States. Seen by Ptolemy, it looks like a star to unaided vision.

Let us add to our open clusters NGC 752 (32^7) with 70 stars, in Andromeda, near Triangulum; NGC 1746 (21^7), 60 stars, within the long horns of the Bull; M35, 120 stars, at the foot of Twin Castor and near the summer solstice; M41, 50 stars, below Sirius in Canis Major; and H12, 200 stars, in the Scorpion's tail. Also, in Sagittarius, M23, 120 stars; and M25, 50 stars. From Vulpecula, near the Cygnus line, we shall pick NGC 6940 (8^7), 100 stars, and from Cassiopeia, under the chair, NGC 7789 (30^6), rich with 200 stars.

If we were using larger amateur telescopes, we should wish to substitute for three of these the beautiful many-starred clusters of M37 in Auriga, NGC 2477 (535△) in Puppis, and M11 at the top of Scutum. But they are not spectacular through small apertures.



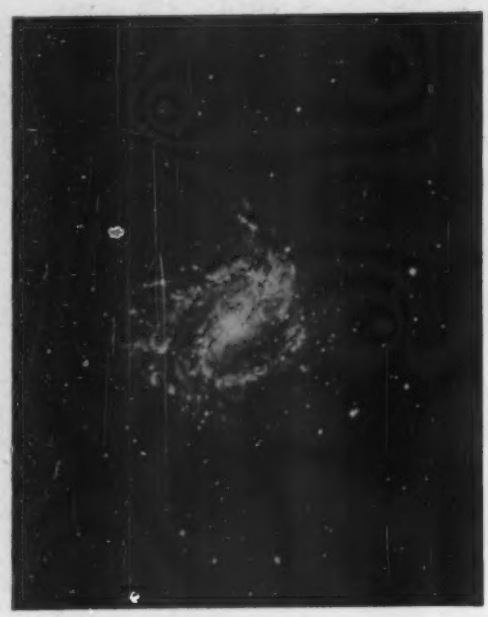
M97, the Owl nebula, is a planetary that bears resemblance to the eyes and beak of an owl. Lick Observatory photo.

The Omega or Horseshoe Nebula, M17, among the rarities of that summer treasure house, Sagittarius, should be listed, though larger telescopes are needed to bring out its beauty and to show why it is called Horseshoe. Tentatively let us write down also M20, the Trifid, near M8, the Lagoon. But with small instruments we shall be unable to distinguish the three lobes from which M20 derives its picturesque name.

Ought we not to introduce a few more galaxies, even though they are such ghostly objects that to see them well we must examine observatory photographs? Let us ask for M81, oval; and its neighbor M82, irregular, looking in amateur telescopes like an edge-on and therefore easier to observe. They are near the ears of the Great Bear. Also we shall need M51, the Whirlpool, two dim spots under the handle of the Big Dipper; M101, forming one corner of a triangle, with Alcaid and Mizar of the Dipper handle as the other points; NGC 4594 (43^1), the Sombrero, intrinsically brightest, on the Virgo-Corvus frontier; roundish M83, in Hydra, near the Centaur's head; NGC 55 and NGC 253, choice marvels of the southern constellation Sculptor. Just to find these wonders is enough — all more than a million light-years distant, each another universe, and each, we may speculate, having an unknown number of inhabited planets.

Double stars are so numerous that we successfully cannot garner a few to reveal the charms of a vast number. After setting down one's choice of such well-known favorites as Mizar, quadruple Epsilon Lyrae, and blue-gold Albireo, especially appealing are Nu Draconis and Mu Sagittarii, the latter a balanced triple. The gamma stars of Virgo, Leo, Andromeda, Aries, and Delphinus merit repeated observation. Gamma Arietis suggests two little girls in blue. Let us add Delta Cephei, yellow and bluish white, interesting in itself and because it was the first of the Cepheid variables, stars which have enabled astronomers to measure the distances between earth and the nearest and partly resolvable galaxies. And let us not forget Zeta Aquarii, a close double, at the center of the Water Jar and nearly on the celestial equator; or 61 Cygni, a double orange, the star whose distance was first measured. Then we should like to register Rigel of Orion, a blue boy with a companion on his shoulder, though this specimen will be difficult for small telescopes. Must we omit Alpha Herculis and Cor Caroli and Castor? Yes, if the list is to be concluded at 60 there isn't space for all the good ones.

Let us select also one colorful star. Shall it be blood-red La Superba, near Alpha and Beta in Canes Venatici, or



The spiral galaxy M83, in Hydra, photographed with the 60-inch telescope at Harvard's southern station.

Mu Cephei, Herschel's garnet or orange star?

When friends would look starward through your telescope, choose one of each kind of celestial marvel. By this plan you will provide a more profitable program than usually can be granted to visitors at observatories and planetariums. Where so many wish to look through one large telescope, only two or three objects can be shown. Sometimes spectators are disappointed. Once at Mount Wilson Observatory the visitors waited nearly an hour for the dome of the 60-inch to open. That night globular cluster M13 was shown, but the power was so great that only a small group of stars, without boundaries, could be seen. To most of the spectators such a display was less valuable than a low-power view would have been.

Amateurs who plan to buy telescopes should ponder the merits of light, short-focus refractors. They do not look impressive, but they are truly serviceable. Not only are they easily operated, but they can be transported about a rear yard to sheltered spots, whenever neighbors turn on troublesome lights, or can be taken to dark or lofty distant locations. Larger telescopes require so much time to get ready, to manipulate, and to cover up, that much can be said in favor of smaller instruments. After all, to get detailed views of most celestial wonders, we must study photographs from great observatories. Just to find these major marvels is enough when we look through amateur telescopes.

IN SUBMITTING this article of interest to all observing amateurs, Mr. Copeland, who operates a bookshop at 1124 State Street, Santa Barbara, Calif., and who for many years contributed observing material to **Sky and Telescope**, writes:

"I have a new 4½-inch refractor. When I had the 16-inch reflector [in a mountain observatory], I was much pleased with its 3-inch short-focus finder. I asked Mr. John Mellish to make a telescope like it, but larger — as light, as inexpensive, and as powerful as possible. The tube is only about 30 inches long, and the complete outfit weighs less than 25 pounds. The altazimuth mounting is aluminum; tripod wooden; no ratchet; just one eyepiece and no diagonals — the downright essentials.

"For the first time I can look at the stars without prelude or postlude — ceremonies of uncovering and veiling. Through this Little Giant I already have seen 10 galaxies, despite the light and the moist night air of Santa Barbara.

"Enclosed is a roundup of 60 of the best objects for amateur observation with small telescopes. You have given considerable space to deep-sky wonders, but so far you have not staged a general rodeo. I have included descriptive or narrative details, but only approximate or rough directions for locating each object. Readers desiring positions in right ascension and declination should consult past Deep-Sky Wonders, Norton's **Star Atlas**, or the new **Atlas of the Heavens.**"

IN FOCUS

(Continued from page 214)

The lower gear is used for slewing (fast motion), 1/8 r.p.m., and the upper gear for tracking and slow setting speeds, thus allowing a minimum of wear on the "fine" worm wheel. A two-horsepower motor is used for slewing, but only 1/12 horsepower is needed for tracking. Clutching of the proper gear is accomplished by taking up the end thrust on the worm to be used by a differential area hydraulic ram. Only that worm and wheel with the fixed end thrust will carry load; the other worm floats. As a final protection against mechanical overload, the worm drive housing is frictionally held in a reference position. These references are marked by precision limit switches which disconnect controls and sound alarms whenever a slip occurs. Hydraulic jacks provide damping to absorb shock movement and also provide the means to reset to the reference position. During the comparatively high-speed slewing motions, all slow-speed operations except indicator dials are declutched by a zero-speed switch. The acceleration rate is controlled by torque characteristics of the motor and added flywheel inertia, which is made large compared to telescope inertia to mask out bearing friction effects. A motor brake provides the proper deceleration torque. The observer has full hand control of the directions of telescope motion at any of three speeds.

Below the driving gears can be seen the computer and the driving and tracking motors. The computer receives hour angle and declination angle from the telescope together with correction increments which will eventually compensate for residual structural, gear, and refraction errors. Addition through differentials gives the correct hour angle, which on comparison with sidereal time gives the true right-ascension angle being observed. This angle is read at all observing stations by precision Selsyn receivers in groups of three, one each for hours, minutes, and seconds. By setting a similar group of Selsyns at the control desk to a desired position, and comparing this position with the existing right ascension position, the controls automatically bring the telescope to the desired position with all corrections included.

Immediately below the figure of the man examining the control board is a new innovation in telescope drive equipment, the phantom or dummy telescope. This instrument is a midget, pivoted with two axes of rotation such that it reproduces the real telescope motions. By means of contacts made by the arm near the horizon in any direction it provides an artificial horizon limit for automatic controls; by transmitting the tube azimuth rotation to the dome-drive unit the dome is rotated automatically to keep the shutter opening always in line with the telescope tube; the movement of the phantom arm from the vertical provides remote meter readings of zenith distance; and, in addition, this zenith distance is used to keep the canvas wind screen automatically following the telescope tube up or down.

The drive at sidereal and tracking rate is provided by means of synchronous motors supplied with controlled frequency power from accurate yet variable frequency standards. This is in contrast with the usual mechanical governor type of drive for most telescopes. Two Warren time standards are used, one fixed for constant sidereal time and the other for variable rate as required for tracking. Each standard consists of a vertically loaded wire vibrating in a single mode. A small bar magnet attached at the midpoint of the properly proportioned wire material is coupled with pick-up and feedback coils to a simple amplifier which maintains the wire in vibration at its fundamental frequency substantially independent of temperature or amplitude. This fundamental is initially adjusted by the tensioning mass to 60 cycles per sidereal second and will maintain this frequency to less than one part per million. The variable rate standard can be linearly varied up to plus or minus five per cent by applying a small direct current in a stationary coil below an Alnico magnet built into the wire tensioning weight. The telescope drive rate, as determined by a potentiometer in the mechanical computer, automatically adjusts the frequency of the tracking standard to provide the proper rate. For manual or superposed planetary rates, a separate motorized potentiometer is operated from the control desk with the rates indicated by an ammeter calibrated in seconds of arc per hour deviation from sidereal rate. The output from these standards controls simple direct current to alternating current vibrator converters which supply the controlled frequency power to the various motors.

Corrections and superposed rate for the declination drive unit are supplied by Selsyn-controlled motors from the computer and desk. These motors drive through mechanical rate integrators to prevent sudden changes in applied rate.

LETTERS

Sir:

I* enjoyed reading the article by Dr. Roy K. Marshall concerning the dismantling of the Philadelphia planetarium instrument and the repair of the ball bearing. It is lucidly written and it is easy to follow every step of the procedure. The repair of the bearing — the regrinding of the double inner races and the installment of two new outer races — seems to have been carried out carefully and expertly, and I express my appreciation to all who worked on this job. They took great care to avoid any damage to the delicate parts of the instrument.

It is not surprising that after 15 years of intensive operation, as a result of natural wear and tear, the much-used ball bearing would be the first part needing repair. Some years ago we did the same job on the planetarium instrument at Jena. Ever since 1926 this instrument had often been used for experimental purposes, in addition to its regular use for demonstrations. We too had been warned by the "clicking or snapping noises" during the diurnal motion and by a slight tilting of the two large disks which carry the commutator rings. When we dismantled the instrument, we found that in the large ball bearing for the diurnal motion some play had developed through wear and tear of the races rather than of the balls.

In designing the planetarium instrument we realized that wear and tear had to be expected in view of the many mechanisms involved. We therefore took great care to construct all elements in such a way as to assure the longest possible life expectancy for all parts. Our greatest concern was the wear which the sliding springs and the sliding contacts probably would have to stand. But according to our experience these have so far not given any trouble.

There is good reason that the ball bearing of the diurnal motion must stand much stress. The length of this bearing as well as its diameter had to be as small as possible in order to keep the dimensions of the total design within reasonable limits. Even so, one may notice that in certain positions rays from the Milky Way projector of the lower fixed star ball strike the network of the carriage, resulting in slight shadows of parts of this network in the Milky Way image (near the horizon).

The bearing itself is so constructed that the thrust between the balls and the races is at 45 degrees against the axis of the bearing. Therefore the effective length of the bearing is determined by the distance between the two points where the thrusts intersect the bearing axis. The effective length of the bearing is therefore not so short as Dr. Marshall assumes. It is decidedly adequate in proportion to the dimensions of the whole design.

As far as the balancing of the instrument is concerned, I wish to point out that we attached greatest importance to the precise balancing of the horizontal axis because only a small worm gear could be placed there for the polar height setting. The balancing of the other two axes (the polar axis for the diurnal revolution and the ecliptic axis for the precession revolution) was well taken care of in the general design by arranging all parts as symmetrically as possible. Owing to the weight of the various instrument parts, the load which the respective bearings have to carry is so great that small deviations from perfect balancing may be disregarded. There is, of course, no objection to attempting perfect balancing of the other two axes, provided the additional weight that may be necessary for attaining this balance be only a very small fraction of the total weight. In our Jena instrument we never found that the slight unilateral deviations in weight of the diurnal and the precession axes gave rise to any noise in the motors or were otherwise noticeable. As mentioned above, it was only when play developed in the ball bearing of the diurnal motion that a noise was noticed, just as in the Philadelphia instrument. I fully approve of the installation of a cage when the ball bearing of the Philadelphia planetarium was repaired. We would do the same today.

In his article, Dr. Marshall says: "The manufacturer didn't want this plate to come off!" This I most emphatically deny. The planetarium is constructed in such a way that the instrument may at any time be completely taken apart without the necessity of destroying a single unit. But we certainly have taken utmost care to prevent any screws from getting loose, especially in those places which are difficult to reach.

I am confident that the critical examination of the ball bearing material made by the experts of SKF Industries in Philadelphia has convinced Dr. Marshall that the material used for the races as well as the balls was good. According to Zeiss tradition the best material and workmanship and the most advanced technique of heat treatment (known to science 20 years ago) were applied.

The degree of finish of the various parts is based on the function these parts have to fulfill. For instance we did not feel that it was necessary for some axles to be finished to the highest degree. An axle which had merely to drive a gear did not require a fine finish. But if an axle was to be fitted into a bearing, it certainly was given the very finest finish.

During the last 20 years, only two of 27 planetarium instruments needed repairs that required the dismantling of parts of the instruments. This fact speaks for the excellence of the design, which comprises an exceedingly great number of anything but simple mechanisms. We believe the continued satisfactory performance of the many Zeiss planetarium instruments in use has proven them to be mechanically substantial.

WALTER BAUERSFELD

*Dr. Walter Bauersfeld, the inventor of the Zeiss planetarium instrument, wrote a letter in answer to the article "Dismantling a Zeiss Planetarium," by Dr. Roy K. Marshall, in the December, 1948, issue of *Sky and Telescope*. The essence of the letter is hereby printed in free translation provided by Dr. K. A. Bauer, Carl Zeiss, Inc., 485 Fifth Avenue, New York City. Dr. Bauersfeld is active as the senior head of the Zeiss Opton Works in the American Zone of Germany. He just finished his 70th year, honored by his many friends at home and abroad. — ED.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evenings, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium,* University of North Carolina, Chapel Hill, N. C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill. Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday and Thursday at 8:30 p.m.; Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Curator, Gordon A. Atwater.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: 3 and 8:30 p.m. daily except Mondays; also 2 p.m. on Saturdays, Sundays, and holidays; 11 a.m. Saturdays, Children's Hour (adults admitted). Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. (Closed July to mid-September.) Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Tuesday and Sunday, 4 p.m. Special showings by request. Admission free. Spitz projector. Director, Ernest T. Ludhe.

BOOKS AND THE SKY

THE ATMOSPHERES OF THE EARTH AND PLANETS

Various authors. University of Chicago Press, Chicago, 1949. 366 pages, 16 plates. $7.50.

A SYMPOSIUM on planetary atmospheres was held in 1947 by the University of Chicago, commemorating the 50th anniversary of Yerkes Observatory. The papers presented at this meeting were edited by Dr. Gerard P. Kuiper and put into book form. Each chapter is therefore written by a different person who is an authority on atmospheric work, and there is a complete bibliography covering the subject of that particular chapter. Name and subject indexes are included, following which appear 16 plates. The introduction (Chapter I) written by Dr. Kuiper serves to tie the whole book together by summarizing what is to come.

Chapter II, "On the Nature of the General Circulation of the Lower Atmosphere," is by Carl-Gustaf Rossby. It deals with observations of pressure, temperature, and wind velocity up to heights of 20 kilometers by radiosonde techniques, made at various Northern Hemisphere locations during the years 1939-1947. Earlier pictures of the earth's atmosphere must be modified considerably. Many diagrams are used to show wind velocity, temperature, and pressure in cross-sections of the atmosphere above various parts of the earth.

The third chapter deals with "Scattering in the Atmospheres of the Earth and the Planets," by H. C. van de Hulst, and explains many of the basic concepts necessary in order to interpret any night sky observations, especially if heights to the emitting layer are to be determined. The author carefully explains the methods for measuring extinction, and in the section under causes of extinction a table is given showing the observed optical thickness and pure air optical thickness for various wave lengths from 3530 to 10,300 angstroms at Mount Wilson. Determination of the altitude of the emission layers is discussed in order to show how extinction and scattering enter the picture. This section summarizes the work done by Barbier and by Piotrowsky, indicating the methods used to determine the height theoretically. Some calculations on scattering in the atmospheres of the planets bring in the problems of single and multiple scattering as well as the phase function of the planet.

Chapter IV, by three writers, deals with "The Upper Atmosphere Studied from Rockets." J. L. Greenstein first discusses the research program in general, describing the agencies interested and the rockets themselves. Actual results are given, most of which have to do with solar radiation and the solar spectrum. Finally, some interesting experiments which might be made in the future are listed. H. E. Clearman then tells about the ultraviolet solar spectrum. He shows how a rocket spectrograph was made and the difficulties encountered. The results obtained involved line identification in the solar spectrum. E. Durand describes the rocket sonde research at the Naval Research Laboratory. The aim here is to determine temperature, pressure, ozone distribution, and solar energy distribution, for which data are presented in clear and well-defined graphs.

Chapter V, on seasonal variations in the density of the upper atmosphere, by Fred L. Whipple, Luigi Jacchia, and Zdenek Kopal, contains a summary of data as obtained from Harvard meteor patrol plates Atmospheric densities have been derived from measured meteor velocities and decelerations, and from their masses as obtained by integration of their light-intensity curves.

The paper by P. Swings gives the reader a complete picture of the lines identified in the night sky, twilight, and aurorae spectra. This subject is currently being studied in an observational way, and Swings has said, "A satisfactory understanding of the spectra of the night sky and of the aurorae requires a considerable amount of further observational, theoretical, and experimental research." A discussion is made of the physical properties, possible origin, and mechanisms of excitation of the green oxygen line and the sodium D line. He also discusses the determination of the height to the emission layer, and summarizes the values pre-

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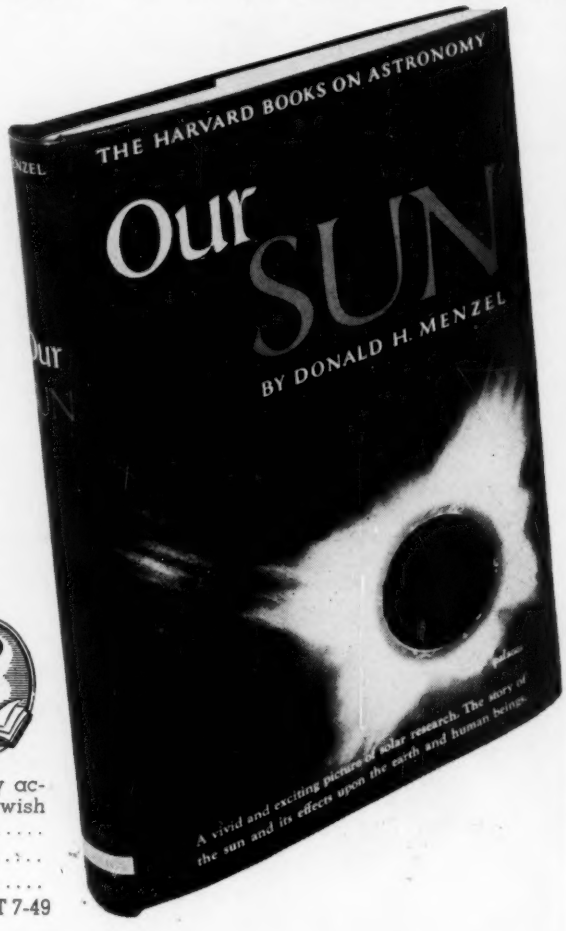
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viously obtained, showing how inaccurate they are and how few are the observations from which they were determined.

Lyman Spitzer, Jr., discusses in Chapter VII the composition, temperature, and nature of the upper atmosphere above 300 kilometers. He gives the formulae used in analysis as well as a complete list of references. A good summary brings together the actual physical results.

"Geological Evidence on the Evolution of the Earth's Atmosphere" is given by Rollin T. Chamberlin in Chapter VIII. The author suggests in his concluding paragraph that the evolution of the earth's atmosphere can be traced by studying the atmospheres of the other similar planets, Mars and Venus.

Chapter IX, "Rare Gases and the Formation of the Earth's Atmosphere," is by Harrison Brown. The abundance of rare gases in the earth's atmosphere as well as in rocks is shown. Then the cosmic abundances of the rare gases are given, and this conclusion is drawn: "It appears that the earth's atmosphere is almost entirely of secondary origin, and it was formed as the result of chemical processes that took place subsequent to the formation of the planet."

Chapter X deals with "Selected Topics in the Infrared Spectroscopy of the Solar System," by Arthur Adel. First, molecular identifications of the atmospheres of the earth, Mars, and Venus are made by close examination of the telluric lines. Here is shown how small and inaccessible quantities of polyatomic or polar diatomic compounds in the earth's atmosphere may be discovered. Methods to obtain the atmospheric and surface temperatures of the earth, Mars, and Venus are described. Then a few paragraphs are devoted to a short discussion by M. V. Migeotte, showing that methane, nitrous oxide, and ammonia bands have been discovered in the earth's atmosphere.

Theodore Dunham, Jr., discusses "Spectroscopic Observations of the Planets at Mount Wilson." The coude spectrograph with the 100-inch telescope was the instrument used for the planetary spectrograms. Unsuccessful attempts were made to obtain absorption lines from Mercury. Water and carbon dioxide bands were found in the atmosphere of Venus, but the search for formaldehyde was unsuccessful. Three methods are discussed which can be used to distinguish the weak absorption lines due to oxygen and water in the Martian atmosphere. The conclusion drawn is that "it seems unlikely that there is more than about 0.0015 as much water vapor above the surface of Mars as there is above Mount Wilson on an average clear night in winter." The rest of the chapter is devoted to the atmospheric compositions and temperatures of the major planets.

Chapter XII is a "Survey of Planetary Atmospheres" by Gerard P. Kuiper. First a complete explanation accompanied by some very good tables gives the physical picture of planetary atmospheres. Then the planetary spectra are discussed, including a table showing atmospheric compositions of the various planets. The infrared spectrometer at McDonald Observatory is described, including a diagram of this instrument. A discussion about the polar caps on Mars is presented with this interesting remark, "The conclusion is that the Mars polar caps are not composed of CO_2 and are almost certainly composed of H_2O frost at low temperature (much below 0° C.)."

In "Laboratory Absorption Spectra Obtained with Long Paths," G. Herzberg shows how necessary it is to recreate in the laboratory the same absorption spectra as seen in planetary atmospheres so that comparison can be made. Such spectra, at a pressure of about one atmosphere with an optical path of about 5,500 meters, were obtained in the laboratory at Yerkes Observatory. With such a set-up the spectra of oxygen, carbon dioxide, and the hydrogen molecule were obtained.

The last two pages in the book are devoted to Chapter XIV, "Possibility of Photosynthesis on Mars," by James Franck. Here it is shown that if plant life is responsible for the green markings on Mars, the process of photosynthesis may not necessarily be the same as that which takes place on the earth. In fact, it is possible that the variation in color may be due to a change in the degree of hydration of minerals or salts.

This book is a mine of information and is indispensable to anyone who is working with problems dealing with planetary atmospheres. The information given is complete and well presented. And although it is definitely written for the reader with a technical knowledge of mathematics, astronomy, and geophysics, scientifically minded laymen should find the book of considerable value in bringing them up to date in a very important field.

HELEN B. PETTIT
Naval Ordnance Test Station
Inyokern, Calif.

NEW BOOKS RECEIVED

MUST WE HIDE? *R. E. Lapp*, 1949, *Addison-Wesley*. 182 pages. $3.00.

A book designed to tell some facts about atomic bombing, and on the basis of these facts to postulate some plans for future living in an atomic age at war.

THE HISTORY OF THE CAMBRIDGE OBSERVATORIES, *F. J. M. Stratton*, 1949, *Cambridge University Press*. 26 pages and 8 plates. $1.25.

This book is Volume I of the *Annals* of the Solar Physics Observatory, Cambridge University, England. It describes the work of the Cambridge Observatory and the Solar Physics Observatory, their instruments and personnel, and their merging in 1946.

THE STARS IN OUR HEAVENS, *Peter Lum*, 1948, *Pantheon*. 245 pages. $3.75.

A book of myths and fables about the constellations, illustrated with drawings showing the star configurations and the mythological outlines of the constellations. The tales included come from all countries.

ART AND SCIENTIFIC THOUGHT, *Martin Johnson*, 1949, *Columbia*. 200 pages. $3.00.

An investigation of the differences and likenesses between scientific and artistic attitudes to life, in which the author proposes that these attitudes shed their traditions of mutual antagonism. Leonardo da Vinci is given as the classical example of a scientist in art.

OUR SUN, *Donald H. Menzel*, 1949, *Blakiston*. 326 pages. $4.50.

The eighth book in the Harvard series on astronomy, delayed because of the classification of solar studies during the war, includes many of the new advances in solar research, as well as complete discussion of our nearest star.

Making Your Own Telescope **The Nature of Cosmic Rays**
Atlas of the Heavens **Sky and Telescope**

Sky Publications

Mappa Coelestis Nova **Splendors of the Sky**
Relativity and Its Astronomical Implications **Moon Sets**

MAKING YOUR OWN TELESCOPE, by Allyn J. Thompson, tells the complete story of how to make and mount a 6-inch reflecting telescope, at very low total cost. Excellent for use by telescope making groups. 211 pages, 104 illustrations. **$3.50**; foreign postage 40 cents

THE NATURE OF COSMIC RAYS, by W. F. G. Swann, gives a review of the fundamental physical and atomic principles involved in the study of this most powerful of all cosmic energies. 32 pages. **50 cents**

ATLAS OF THE HEAVENS, by Antonin Becvar and associates at the Skalnate Pleso Observatory. Sixteen charts cover the entire sky to magnitude 7.75, including doubles, multiples, variables, novae; galactic star clusters, globulars, and planetaries; 1950 co-ordinates. Each chart area is 15½ by 23½ inches. **$5.00**

SKY AND TELESCOPE may be sent as a gift; if requested, a donor's card is sent to the recipient of each gift subscription.

MAPPA COELESTIS NOVA, by Josef Klepesta, is a large wall chart, colorful as well as informative. The northern sky to —45° is shown on a polar projection, and each star is colored according to its spectral class. The chart makes a fine transparency, 28 inches square. **$3.50**

SPLENDORS OF THE SKY is a bargain in astronomical photographs, with explanatory captions, now in its third printing for a total of 36,000 copies in eight years. 36 pages, each 8½ x 11½ inches. **35 cents**, plus 5 cents postage

RELATIVITY AND ITS ASTRONOMICAL IMPLICATIONS, by Philipp Frank, is an outstanding explanation of the general theory of relativity, in language suitable for the layman. 24 pages. **50 cents**

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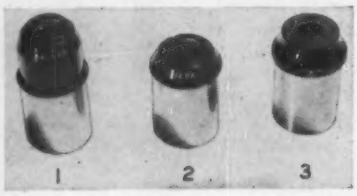

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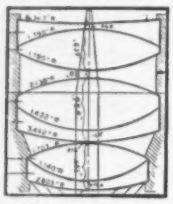

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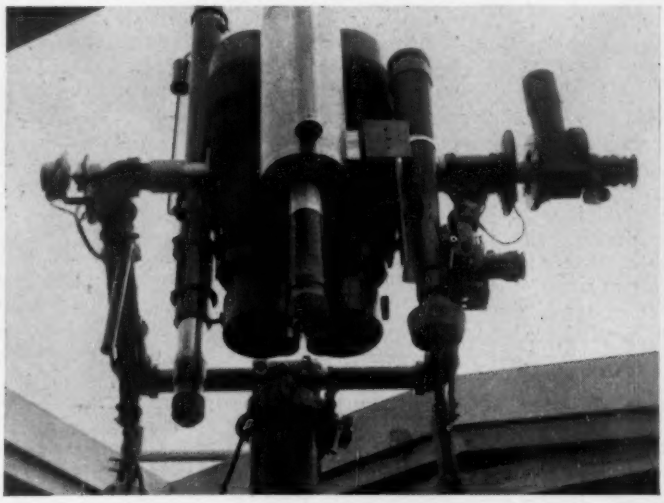
The new Young Observatory is to be used by members of the National Capital Astronomers of Washington, D. C. The building is rectangular in shape and departs in many features from the conventional design. In place of a slide-off roof, five hatchways accommodate instruments mounted on as many steel piers. The main pier supports a pair of 6-inch binoculars with powers from 20x to 100x; two 2½-inch finders of 16x, 4½-degree field, and 30x, 2½-degree field, respectively; and two right-angle finders to guide the instrument.



Principal instruments mounted on this pier in the Young Observatory are 6-inch binoculars with a 5-inch telescope and finder above them. At the left are a Selsyn motor and a 2½-inch finder; to the right are a 2½-inch wide-field finder and a pair of right-angle finders.

The total weight of the main instrument, with finders and counterweights, is about 300 pounds. Structural vibration limits eyepieces to 100x or lower for best results. Binocular vision adds greatly to the pleasure of looking at the moon, the planets, and star clusters.

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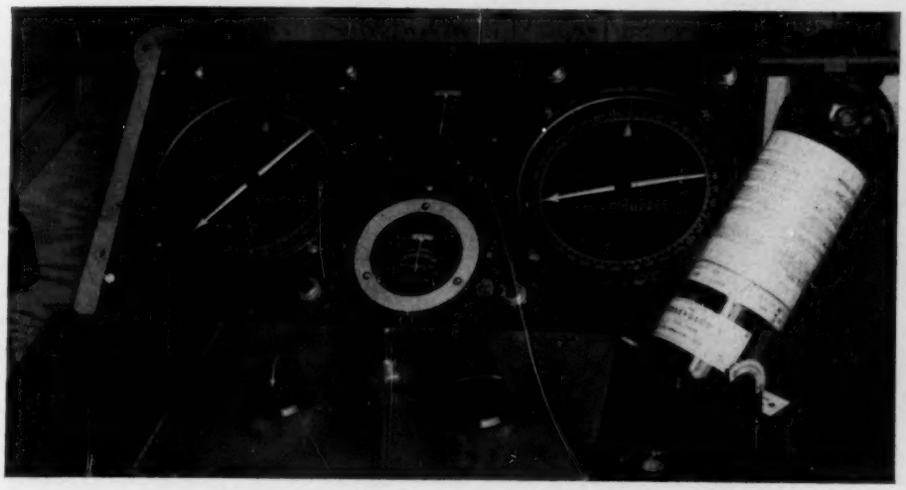

The remote control panel for the main pier of the Young Observatory, on which instruments are mounted in altitude-azimuth co-ordinates.

The illustration shows the remote control panel for the 6-inch binoculars. The dial at the left indicates azimuth angle, that on the right shows vertical angle. The middle dials show speed and direction of tracking. Six push buttons reverse the horizontal and vertical motors, turn on the Selsyn motors and dial lights. Two rheostats in the foreground control the speeds of the driving motors. The Observoscope on the right is mounted permanently, so that the apparent positions and altitude-azimuth angles of celestial objects can be determined in order to direct the binoculars to the desired positions in the sky.

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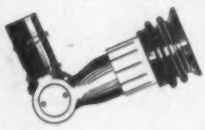

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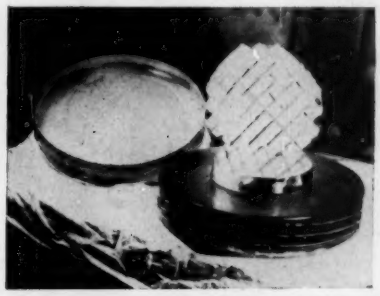

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loops for the pin reamed out to fit a turned-true pin with a locking nut, which enables the butt to be held firmly. One side of the butt had a hole partially cut into it for the head of the bolt to fit into while the hinge is tightly closed.

The slide has a groove cut to the size of two bolts extending from the leg of the tripod, and this enables the slide to be moved up or down without losing the object being viewed in the sky.

It was hard to find an object with the 60-mm. telescope on account of the offset part holding the eyepiece. Looking through some old copies of **Sky and Telescope,** I found that an amateur had used an open ring that he had filled with phosphorescent powder (Vol. V, No. 12, October, 1946). So I asked my gunsmith mechanic to construct a sight for my 60-mm. scope. With it I can get a star of the 3rd or 4th magnitude into the field quickly. A 6-power finder was also attached alongside, and when a star is in the sight it is in the finder, and over half of the time it is in the main instrument with the 60-power eyepiece. A flashlight charges the sight ring for many minutes.

I also have a pair of 10 x 80 binoculars, and their mounting is on a tripod on the same lines as the others. To look at ground sports or boat racing, a butt is used that permits sidewise swivel.

This very inexpensive tripod will hold an instrument steady, even in a good breeze. It is easily carried in my automobile, and I generally take one or more of the instruments with me on trips. When showing stars and planets to boy scouts and others, the raising and lowering feature comes in quite handy.

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"NEW THEORY of Cosmic Motion" explains how electric and magnetic forces may cause motions of stars and planets. Gives new evidence that space resists the motions of the planets, thus indicating the possible existence of an "ether." Gives new theory of the solar system. Offers non-relativistic explanation of Mercury's spiral orbit. All in plain English, easily understood. Copies $1.00 postpaid, or write for free sample page. Frank L. Daniels, 4011 Fairfield, Fort Wayne 6, Ind.

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TELESCOPES & ACCESSORIES: If you want good optics and accessories for your astronomical studies, send for our catalogue. We will also submit prices on photometers and associated equipment for stellar photometry. Laboratory Optical Co., 76 Interhaven Ave., Plainfield, N. J.

BUSCH BINOCULAR, pill box, coated optics, 80-mm. objective, 10x magnification. Mounted on sturdy adjustable tripod. Fine for observation and spotting purposes. Value $400.00 new, reconditioned price $250.00 complete. Send for our 8-page list of camera and projector bargains. All leading makes. Paul L. Brand & Son, 2153 K St. N. W., Washington 7, D. C.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

The Bright Satellites of Jupiter

A NEVER-ENDING source of fascination to the amateur telescopist are the four bright satellites of Jupiter. This miniature solar system is comprised of the first heavenly objects discovered by Galileo in 1610. Also, these satellites served Roemer in 1675, when he made the first measurement of the speed of light.

The Galilean satellites of Jupiter are said to have been seen with the naked eye. They may easily be viewed, however, in binoculars of six to eight power. They are of mean magnitudes 5.5, 6.1, 5.1, and 6.2, respectively, at mean opposition, and might be seen with the unaided eye were it not for the nearby disk of bright Jupiter. These four moons all have disks when observed in a telescope of moderate aperture (1″.05, 0″.85, 1″.51, and 1″.43 at mean distance of 5.2 astronomical units). Masking the bright planetary disk is helpful in observing Jupiter's satellites. No permanent markings have been seen on them. Atmospheres such as Jupiter's have been suspected on satellites **III** and **IV**, Ganymede and Callisto, which are both larger than the planet Mercury. At opposition, Ganymede has a stellar magnitude of 5.1, and it would outshine Mercury and Mars if all three were placed at the same distance from the sun.

Transits of the satellites and their shadows across Jupiter's disk are exceedingly interesting. Depending on the relative positions of the earth and Jupiter, either the moon or its shadow may appear first on the primary's disk. Opposition of the planet to the sun takes place on July 20th this year, and examination of the times given below shows that before that date shadow transits commence before satellite transits, whereas the reverse is true after opposition. Occasionally, two satellites or shadows may be in transit simultaneously, in which case the unequal velocities of the satellites in their orbits may be noticed. Shortly after passing in front of the planet a satellite blends with the bright disk and may be difficult to discern. Russell, Dugan, and Stewart (**Astronomy**, Vol. I) state that satellite **II** (Europa) is always bright in comparison to Jupiter's surface itself; **I** (Io) is bright except against the brightest parts of the disk; **III** is darkish except when near the limb; and **IV** is grayish even near the limb, and is almost black at mid-transit. In small instruments, however, these effects may seem slightly different. Satellite **II**, for instance, may appear to vanish at mid-transit, where Jupiter's disk is itself brightest.

As for eclipses and occultations, usually a satellite is eclipsed and then occulted before opposition, or occulted and then eclipsed after opposition; again inspect the times below before and after July 20th. For a diagram of this effect, see page 198 of last month's issue of **Sky and Telescope.**

This year, instead of publishing the usual monthly chart of the arrangements of the satellites with reference to Jupiter for **one** specific time only, we give the times of all phenomena observable from any part of the United States when Jupiter is above the horizon after dark. The chart information is also included, by means of the group of numbers immediately following the date in each case. All information has been obtained from the **American Ephemeris and Nautical Almanac.** Standard textbooks may be consulted for the characteristics of the satellites.

Mean synodic periods of the satellites are: **I**, $1^d\ 18^h\ 28^m.6$; **II**, $3^d\ 13^h\ 17^m.9$; **III**, $7^d\ 3^h\ 59^m.6$; **IV**, $16^d\ 18^h\ 5^m.1$.

EDWARD ORAVEC

PHENOMENA OF JUPITER'S SATELLITES

July 1, 3024; 2:19 III ShE, 3:47 I Sh, 4:14 III TrE, 4:15 I Tr, 6:04 I ShE, 6:32 I TrE. **2,** 32014; 3:52 I OcR. **3,** 31204. **4,** 30124. **5,** 10234; 5:52 II Sh, 6:36 II Tr, 8:39 II ShE, 9:24 II TrE. **6,** 20134. **7,** 10243; 3:32 II OcR, 8:33 I Ec. **8,** 402; 2:30 IV TrE, 2:46 III Sh, 3:58 III Tr, 5:41 I Sh, 5:59 I Tr, 6:18 III ShE, 7:32 III TrE, 7:59 I ShE, 8:17 I TrE. **9,** 43201; 3:01 I Ec, 5:36 I OcR. **10,** 43210; 2:27 I ShE, 2:43 I TrE.

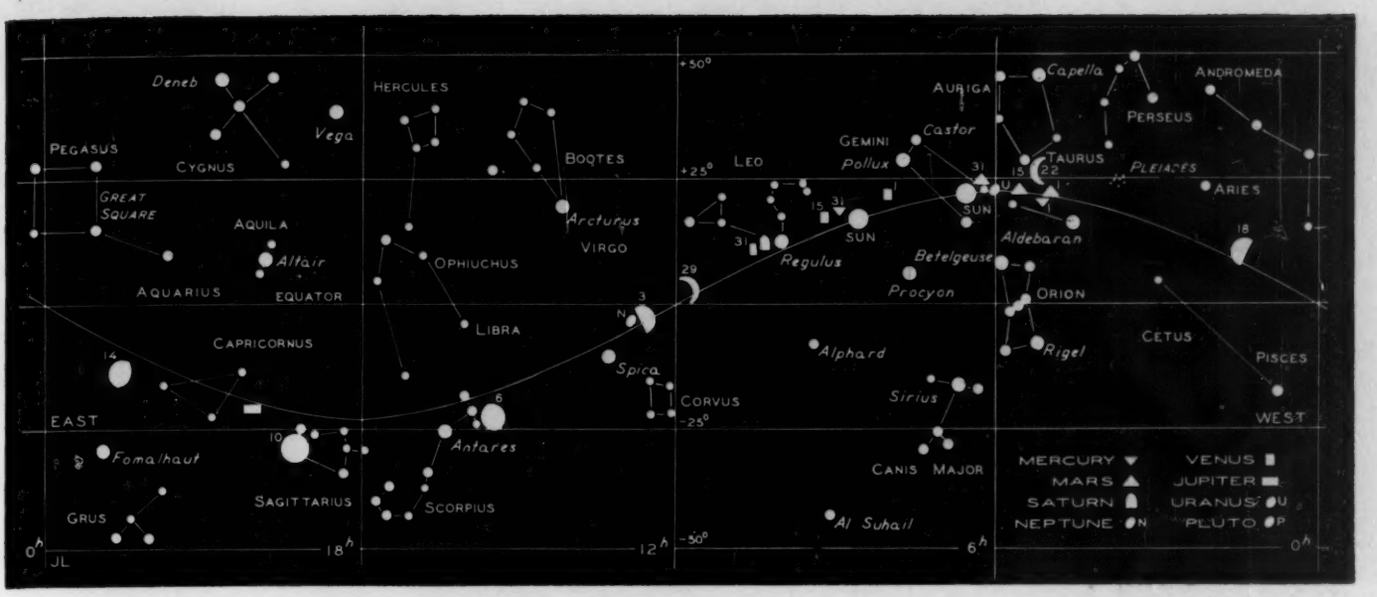
July 11, 43012. **12,** 41023; 8:27 II Sh, 8:51 II Tr. **13,** 42013. **14,** 41023; 2:38 II Ec, 5:47 II OcR, 10:27 I Ec. **15,** 40312; 6:46 III Sh, 7:15 III Tr, 7:36 I Sh, 7:43 I Tr, 9:53 I ShE, 10:01 I TrE, 10:18 III ShE, 10:49 III TrE. **16,** 320; 4:56 I Ec, 5:07 IV Ec, 7:19 I OcR, 10:12 IV OcR. **17,** 32104; 2:04 I Sh, 2:09 I Tr, 4:22 I ShE, 4:27 I TrE. **18,** 30124; 1:45 I Oc. **19,** 10234. **20,** 20134.

July 21, 1034; 5:12 II Oc, 8:04 II EcR. **22,** 03124; 9:27 I Tr, 9:30 I Sh, 10:32 III Tr, 10:45 III Sh. **23,** 32104; 2:59 II TrE, 3:07 II ShE, 6:46 I Oc, 9:07 I EcR. **24,** 3204; 3:53 I Tr, 3:59 I Sh, 6:11 I TrE, 6:16 I ShE. **25,** 34012; 1:12 I Oc, 3:35 I EcR. **26,** 41032; 4:26 III EcR. **27,** 42013. **28,** 41203; 7:27 II Oc, 10:41 II EcR. **29,** 40132; 11:11 I Tr, 11:25 I Sh. **30,** 43120; 2:26 II Tr, 2:55 II Sh, 5:13 II TrE, 5:42 II ShE, 8:30 I Oc, 11:01 I EcR. **31,** 4320; 5:37 I Tr, 5:54 I Sh, 7:55 I TrE, 8:11 I ShE.

August 1, 3402; 2:56 I Oc, 5:30 I EcR. **2,** 1042; 2:21 I TrE, 2:40 I ShE, 3:21 IV EcR, 3:32 III Oc, 8:26 III EcR. **3,** 20134. **4,** 12034; 9:43 II Oc. **5,** 01324. **6,** 13024; 4:40 II Tr, 5:30 II Sh, 7:28 II TrE, 8:18 II ShE, 10:14 I Oc. **7,** 32014; 7:22 I Tr, 7:49 I Sh, 9:39 I TrE, 10:06 I ShE. **8,** 31024; 2:38 II EcR, 4:40 I Oc, 7:24 I EcR. **9,** 31024; 1:48 I Tr, 2:18 I Sh, 4:06 I TrE, 4:35 I ShE, 6:52 III Oc. **10,** 2013; 1:53 I EcR, 2:44 IV Tr, 6:54 IV TrE, 7:37 IV Sh, 11:51 IV ShE.

In the accompanying data, taken from the American Ephemeris and Nautical Almanac, following each date (in bold-face type) are given the telescopic satellite positions west (left) or east (right) of Jupiter (which is designated 0) at 6:00 UT in July, and at 4:15 in August.

Then are given the Universal time, the satellite (Roman number), and the phenomenon. Tr and TrE are the beginning and ending, respectively, of a satellite transit; Sh and ShE, same for the shadow; Ec and EcR are eclipse disappearance and reappearance, respectively; Oc and OcR, same for occultation.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury may be seen during the dawn rising 1¼ hours before the sun the first 10 days of July. From western elongation on June 28th the planet will grow brighter as it approaches the sun in the sky, reaching magnitude −1.0 on July 15th. It attains superior conjunction on July 26th.

Venus remains low in the west, about 15° above the horizon at sunset. On July 1st, Castor, Pollux, and Venus will be in a straight line roughly parallel to the horizon. By July 25th, the planet will pass a degree north of Regulus. A close conjunction with Saturn occurs on July 31st, at 6:00 Universal time, Venus being 10′ south geocentrically; in the twilight of July 30th and 31st, Venus will be near the ringed planet, outshining it by over four magnitudes.

Mars leaves the morning twilight on July 10th, rising two hours before sunrise. The planet is of the 2nd magnitude. On July 27th, Mars will pass 16′ north of Uranus at 8:00 Universal time.

Jupiter dominates the midnight sky with its brilliance, coming to opposition on July 20th. Its magnitude is −2.3 and its distance about 380 million miles from the earth. The planet's apparent equatorial diameter is 48″. Elsewhere in this department is a schedule of phenomena of Jupiter's satellites.

Saturn is low in the west when darkness falls, and is of little observational interest.

Uranus reappears in the morning sky of late July, and Mars passes north of it on the 27th, enabling one to locate this distant planet of the 6th magnitude.

Neptune is ½° southwest of 38 Virginis, in the early evening sky. E. O.

OCCULTATION PREDICTIONS

July 19-20 **Delta Arietis** 4.5, 3:08.7 +19-32.1, 24, Im: **A** 6:21.4 +0.3 +1.9 46; **B** 6:27.5 +0.3 +1.9 41; **C** 6:16.5 +0.4 +1.8 47; **D** 6:26.2 +0.4 +1.9 39. Em: **A** 7:18.7 −0.4 +1.6 259; **B** 7:23.0 −0.4 +1.6 265; **C** 7:11.7 −0.2 +1.5 259; **D** 7:18.3 −0.3 +1.5 269.

August 6-7 **A Sagittarii** 5.0, 19:55.8 −26-20.1, 12, Im: **A** 6:48.9 +0.2 +1.0 18; **C** 6:45.7 −0.1 −1.1 19. Em. **A** 7:33.9 −1.5 −2.3 296; **C** 7:34.6 −1.7 −2.1 293.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, all data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +30°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
	I +123°.1, +49°.5		

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

MOON PHASES AND DISTANCE

First quarter	July 3,	8:08
Full moon	July 10,	7:41
Last quarter	July 18,	6:01
New moon	July 25,	19:33
First quarter	August 1,	12:57

	July	Distance	Diameter
Perigee	2d 22h	229,800 miles	32′ 19″
Apogee	17d 2h	251,100 miles	29′ 34″
Perigee	29d 1h	227,600 miles	32′ 38″

MINIMA OF ALGOL

July 2, 7:58; 5, 4:47; 8, 1:36; 10, 22:24; 13, 19:13; 16, 16:01; 19, 12:50; 22, 9:39; 25, 6:27; 28, 3:16; 31, 0:04. August 2, 20:53; 5, 17:42; 8, 14:30.

METEORS IN JULY

This summer, observation of the Perseid meteors in August will be rendered poor by a waning gibbous moon. However, good meteor observing may be had between July 25th and August 4th, with the Delta Aquarid shower reaching maximum on the 28th, and with some Perseids appearing during the same period. Good rates, up to 25 meteors per hour after midnight, may be expected. Few Perseids are seen before midnight, and by July 31st perhaps half of the meteors observed will be Perseids.

The Delta Aquarids, one of the best showers of the year, are typically slow with long paths. Many are of the 1st and 2nd magnitude, yellow, with trains left by perhaps one out of four. The radiant, at right ascension 340°, declination −17°, is on the meridian about 2 a.m. local time. E. O.

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VARIABLE STARS IN SPAIN

A copy of **Urania** recently received in this country contains a lengthy account of plans of the Astronomical Society of Spain and America to inaugurate a section of that organization for the study of variable stars. The project, under the active direction of A. Barangé and A. Esplugas, thus adds another observing group to the already well-established variable star associations in Europe.

The article in question deals with the history of variables, and includes methods of observation and sample charts. Lists of interesting variables in the different classes are given. **Urania** is the organ of the Astronomical Society of Spain and America, in Barcelona, and of the National Union of Astronomy and Allied Sciences, in Madrid.

Fellow variable star associations welcome this new group of variable star observers to their midst.

LEON CAMPBELL
Recorder, AAVSO

VARIABLE STAR MAXIMA

July 1, R Serpentis, 6.8, 154615; 11, T Ursae Majoris, 7.9, 123160; 13, X Monocerotis, 7.6, 065208; 20, R Bootis, 7.3, 143227; 21, T Columbae, 7.6, 051533; 23, T Centauri, 6.1, 133633; 26, RT Hydrae, 7.6, 082405; 30, R Aquilae, 7.3, 233815. August 1, RR Scorpii, 6.0, 165030a; 2, S Coronae Borealis, 7.5, 151731; 8, S Ursae Majoris, 7.9, 123961; 10, X Ophiuchi, 6.9, 183308.

These predictions of variable star maxima are made by Leon Campbell, recorder of the AAVSO, Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

AVAILABILITY OF THE NGC

Referring to Mr. Houston's mention in the December issue that the **New General Catalogue** of Dreyer is out of print, I have recently purchased from the Royal Astronomical Society, Burlington House, London W. 1, England, the following volumes of the **Memoirs** of that organization:

Vol. 49, Part 1, New General Catalogue, £1 0s; Vol. 51, First Index Catalogue, 15s; Vol. 59, Part 2, Second Index Catalogue, 8s.

Postage for the three volumes is one shilling, making the total cost £2 4s, which is $8.91 in United States currency. I paid for mine with an international money order, the charge for which was 10 cents. I received the books exactly a month after ordering them.

The NGC and the second IC are in separate volumes; the first IC is in a volume with a number of unrelated papers.

CAMPBELL WADE, JR.
Elizabethtown, Ky.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown. Daylight time is one hour in advance of standard time.

DEEP-SKY WONDERS

THE MAJORITY of the globular clusters are found toward the Sagittarius-Ophiuchus-Scorpius area, but they are hard to recognize because of the wealth of stars and nebulosity. With the accompanying finder charts amateurs may locate several rather faint clusters deep toward the galactic center.

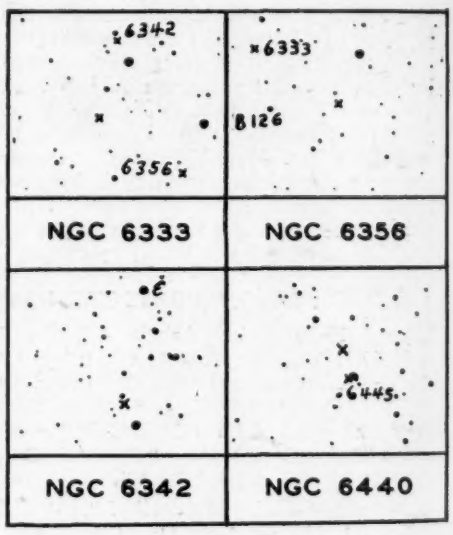
NGC 6333, M9, 17h 16m.2, −18° 28′, diameter 5.5′, magnitude 8.9, distance about 21 kiloparsecs (uncertain). In 1844, Admiral Smyth wrote: "This fine object is composed of a myriad of minute stars, clustering into a blaze in the center, and wonderfully aggregated, with numerous outliers seen by glimpses."

NGC 6356, 48[1], 17h 20m.7, −17° 46′, 3.5′, 9.7, 50 kiloparsecs (uncertain). Discovered by William Herschel on June 17, 1784. The star marked B 126 is a neat triple star, magnitudes 6.4, 7.5, 2″ apart at position angle 260°; and 11.7, 11″ away at 140°, both companions unchanging.

NGC 6342, 149[1], 17h 18m.2, −19° 32′, 1.3′, 11.3, 40 kiloparsecs (uncertain). The NGC describes this cluster as quite bright, rather small, easily resolvable. William Herschel discovered it on May 28, 1786, as he did our next object.

NGC 6440, 150[1], 17h 45m.9, −20° 21′, 1.7′, 12.0, 50 kiloparsecs (uncertain). It is described as pretty bright and large, round, and brighter in the middle.

A few minutes to the north of NGC 6440 lies **NGC 6445,** 586[1], a planetary nebula about 40″ in extent, described in Lick **Publications** XIII as a trapezium-shaped object with very sharp corners; two parallel sides are considerably brighter than the other sides and lie in position angle 60° and 240°. There is no indication of a central star.



The scale of these charts is one centimeter to one degree. South is at the top. Star dots are by magnitude intervals. The limiting magnitude is 9.

A number of readers have written of their inability to locate M33, the open spiral in Triangulum. This column will discuss the matter and the overall problem of the visibility of nebulous objects in a future issue.

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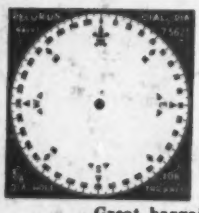

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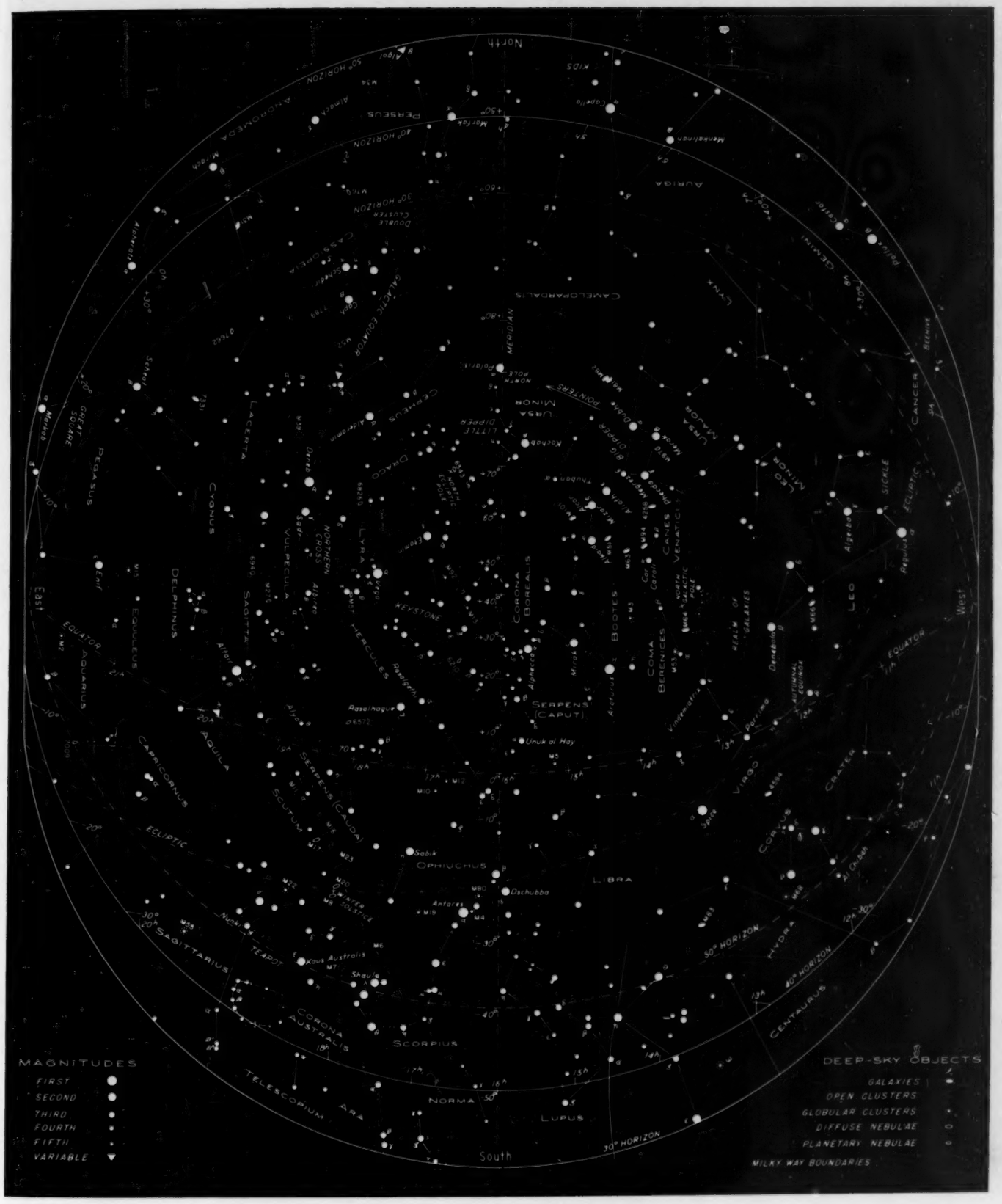

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively.

STARS FOR JULY

SUMMERTIME'S 1st-magnitude stars and its constellations are probably the best known to casual stargazers, who seem to prefer mosquitoes to frostbite. The curve of the Big Dipper's handle leads to Arcturus and on to brilliant Spica, both already west of the meridian in the evening sky. From Arcturus a line traced northeastward will lead to Alphecca, brightest star in the circlet of the Northern Crown, and onward as far again to the Keystone of Hercules. Still farther brings one to brilliant Vega, brightest of the triangle of bright stars, Vega, Altair, and Deneb.

In the south, the Scorpion stretches its length along the meridian, from the triple-starred head through red Antares in its heart, down its body and around to the two bright stars in its tail sting. To the west is fainter Libra, eighth constellation of the zodiac, once thought of as the claws of the Scorpion. Even now, the stars Alpha and Beta in Libra have Arabic names meaning the southern claw and the northern claw. These two names, if well rehearsed, will demonstrate your knowledge and astound your friends — the southernmost star, Alpha Librae, is Zubenelgenubi, and the northern star, Beta, is Zubeneschamali.

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